Contents

8C:P3:HRM8

8-1 BMPs For Controlling Pollutants Other Than Sediment on Construction Sites (Non-ESC BMPS)

8.1.1 BMP C1.10 — Pesticide Control

Although the word “pesticide” has come to mean only those chemicals which attack insect populations, here the word is used to include herbicides and rodenticides as well as chemicals commonly known as pesticides. Insecticides, rodenticides, and herbicides have historically been used on construction sites to increase health and safety, maintain a pleasant environment, and reduce maintenance and fire hazards. Often, rodents are attracted to construction sites and rodenticides are used.

Pesticides should only be used in conjunction with Integrated Pest Management (IPM). IPM utilizes a needs assessment which determines the necessity of controlling a pest population and which method to use. Pesticides should be the tool of last resort; methods which are the least disruptive to the environment and to human health should be used first. IPM is further discussed in Chapter 6, Roadside Vegetation Management.

If pesticides must be used, clearance for use of any of these chemicals is often required by restrictive federal and state regulations. All pesticides should be stored and applied in accordance with regulations of the State Department of Agriculture (WSDA), WAC 16-228-285. The Environmental Protection Agency (EPA) has produced a pamphlet entitled *Suspended, Canceled and Restricted Pesticides* (January 1985) which includes information on many pesticides. As it is more than five years old, it is wise to check with EPA’s Region 10 Pesticides Branch in Seattle, if any questions regarding the use of pesticides arise. An awareness of the need to adhere to recommended dosages, type of application equipment, time of application, cleaning of application equipment, and safe disposal of these chemicals, will go far in limiting the pollution of waterways. Application rates should conform to registered label direction. Many of these compounds are considered “Dangerous Wastes” and must be disposed of properly. Disposal of excess pesticides and pesticide-related wastes should conform to registered label directions for the disposal and storage of pesticides and pesticide containers set forth in applicable federal, state, and local regulations. General disposal procedures are:

- Dispose of through a licensed waste management firm or treatment, storage and disposal company (TSD).
- Use up, or give away to a garden center, landscape service, or similar business.
- Triple rinse containers before disposal, reuse rinse waters as product.

Hazardous Waste Pesticides — Determining if Your Pesticide is a Hazardous Waste, Department of Ecology Publication 89-14, provides guidance and is available from Ecology’s Publications Office. For more information, contact the headquarters hazardous materials specialists in the Environmental Branch, or call Hazards Line (587-3292) or Hazardous Substance Information Hotline (1-800-633-7585).

Pesticide storage areas on the construction site should be enclosed or otherwise protected from the elements (especially rainfall and runoff), from vandals, and from the curious. Warning signals should be placed in areas recently sprayed or treated with the most dangerous pesticides. Persons involved in the mixing and application of these chemicals, to be in compliance with the law, must wear suitable protective clothing.

Other practices include:

- Establish a locked, weather-resistant storage area.
- Container lids should be tightly closed.
- Keep pesticides in a cool, dry place. Many pesticides rapidly lose their effectiveness if stored in areas exposed to heat.
- In case of a leak, put original container into a larger container and label it properly.
- Check containers periodically for leaks or deterioration.
- Keep a list of products in storage.
- Use plastic sheeting to line the storage area.
- The applicator must follow the notification requirements of the WSDA. Neighbors on properties adjacent to the one being sprayed should also be notified prior to spraying.
- All storage sheds, dumpsters or other storage facilities should be regularly monitored for leaks and repaired as necessary. Remind workers during pre-construction or safety meetings about proper storage and handling of materials.

8.1.2 BMP C1.20 — Handling of Petroleum Products

Petroleum products are widely used during construction activities. They are used as fuels and lubricants for vehicular operations, power tools, and general equipment maintenance. These pollutants include oils; fuels such as gasoline, diesel oil and kerosene; lubricating oils; and grease. Petroleum products usually occur, and can become mixed with stormwater, in vehicle storage areas and on-site fueling or equipment maintenance areas. Most of these pollutants adhere to soil particles and other surfaces easily.

One of the best modes of control is to retain sediments containing oil on the construction site. Soil erosion and sediment control practices can effectively accomplish this. Improved maintenance and safe storage facilities will reduce the chances of petroleum products contaminating construction sites. One of the greatest concerns confronting uses of petroleum products is the method for waste disposal. Oil and oily wastes such as crankcase oil, cans, rags, and paper dropped in oils and lubricants, can be best disposed of in proper receptacles or recycled (call 1-800-RECYCLE). Contact the headquarters hazardous materials specialists in the Environmental Branch for more information on recycling and disposal. Waste oil for recycling should not be mixed with degreasers, solvents, antifreeze, or brake fluid. The dumping of these wastes in sewers and other drainage channels is illegal and could result in fines or job shutdown. A further source of these pollutants is leaky vehicles. Proper maintenance of equipment and installation of proper stream crossings will further reduce pollution of water by these sources. Stream crossings should be minimized through proper planning of access roads.

Guidelines for storing petroleum products are as follows:

- Store products in weather-resistant sheds where possible.
- Create shelter around storage area with cover and wind protection, and construct impervious berm around the perimeter of storage area.
- Capacity of bermed area should be 110 percent of largest container.
- Line the storage area with double layer of plastic sheeting or similar material.
- All products should be clearly labeled.
- Keep tanks off the ground.
- Keep lids securely fastened.
- Post information for procedures in case of spills. Persons trained in handling spills should be on-site or on call at all times.
- Materials for cleaning up spills should be kept on-site and easily available. Spills should be cleaned up immediately and the contaminated material properly disposed of.
- Specify a staging area for all vehicle maintenance activities. This area should be located away from all drainage courses.
- All storage sheds, dumpsters, or other storage facilities should be regularly monitored for leaks and repaired as necessary. Remind workers during subcontractor or safety meetings about proper storage and handling of materials.

8.1.3 BMP C1.30 — Nutrient Application and Control

Inorganic nutrient pollution is most often caused by fertilizers used in revegetating graded areas. The use of proper soil-stabilization measures, sediment control, and stormwater detention structures can be effective means of keeping these materials out of waterways. Only small amounts of inorganic nutrients are beneficial to the productivity of waterways, while excess amounts result in over-enrichment and can contribute to eutrophication.

Nutrient pollution can be minimized by working fertilizers and liming materials into the soil to depths of 4 to 6 inches, and by proper timing of the application. Hydro-seeding operations, in which seed, fertilizers and lime are applied to the ground surface in a one-step operation, are more conducive to nutrient pollution than are conventional seedbed-preparation operations, where the fertilizers and lime are tilled into the soil. In the case of surface dressings, control can be achieved by applying the required quantity of fertilizer in more than one operation. For example, an area requiring an application of 500 pounds per acre of fertilizer could be dressed with about 125 pounds per acre at four separate times over the growing season.

Use of fertilizers containing little or no phosphorus may be required by local authorities if the development is near sensitive water bodies. In any event, great care should be taken to use only the minimum amount of phosphorus needed, as determined by soil tests, or advice from district or Headquarters landscape architects.

Near sensitive surface waters, the addition of lime can affect the pH (or acidity) of runoff and receiving waters. Importation of topsoil is better than heavily liming and fertilizing exposed subsoil.

8.1.4 BMP C1.40 — Solid Waste Handling And Disposal

Solid waste is one of the major pollutants caused by construction. Solid waste is generated from trees and shrubs removed during land clearing for road construction and during the installation of structures, and from the demolition of structures. Other wastes include wood and paper from packaging and building materials, scrap metals, sanitary wastes, rubber, plastic and glass pieces, masonry products, and other materials. Food containers such as beverage cans, coffee cups, lunch-wrapping paper and plastic, cigarette packages, leftover food, and aluminum foil contribute a substantial amount of solid waste to the construction site.

The major control mechanism for these pollutants is to provide adequate disposal facilities. Collected solid waste should be removed and disposed of at authorized disposal areas. Frequent garbage removal helps maintain clean construction sites and minimizes the exposure of waste to stormwater. Waste containers should be labeled and located in a covered area. Lids should be kept closed at all times. Any useful materials should be salvaged and recycled. For instance, masonry waste can be used for filling borrow pits; trees and brush from land clearing can be converted into wood chips through mechanical chippers and then used as mulch in graded areas. Sanitary facilities must be convenient and well maintained to avoid indiscriminate soiling of adjacent areas. Selective (rather than wholesale) removal of trees is helpful in control of soil erosion and reduction of wood wastes. Indiscriminate removal of trees and other beneficial vegetation should be avoided.

Soil erosion and sediment control structures capture much of the solid waste from construction sites. Constant removal of litter from these structures will reduce the amount of solid waste despoiling the landscape. The extension of local and state anti-litter ordinances to cover construction sites is also a viable control mechanism. Adherence to these regulations by construction personnel reduces unnecessary littering through carelessness and negligence.

8.1.5 BMP C1.50 — Use of Chemicals During Construction

Many types of chemicals may be used during construction activities. These chemicals are found in paints, acids for cleaning masonry surfaces, cleaning solvents, asphalt products, soil additives used for stabilization and other purposes, concrete-curing compounds, and many others. When used or stored improperly, these chemicals can become mixed with stormwater and carried by sediment and runoff from construction sites.

A large percentage of these chemicals can be effectively controlled through implementation of source control soil erosion and sedimentation control practices. By using only the recommended amounts of these materials and applying them in a proper manner, pollution can be further reduced. As in the case of other pollutants, good housekeeping is the most important means of controlling pollution.

The correct method of disposal of wastes varies with the material. Wash-up waters from water-based paints may go into a sanitary sewer, but wastes from oil-based paints, cleaning solvents, thinners, and mineral spirits must be disposed of through a licensed waste management firm or TSD. Disposal of concrete products, additives, and curing compounds depends on the product. Information is available from the headquarters hazardous materials specialists in the Environmental Branch, local health department or the Hazardous Substance Information Hotline (1-800-633-7585).

8.1.6 BMP C1.60 — Managing Hazardous Products

Listed below are general guidelines for managing or minimizing hazardous substances used at construction sites:

- Buy and use only what is needed. Leftovers need to be stored, reused, given away, recycled, or disposed of safely.
- Read labels and follow directions on the label. Hazardous products may include one or more of the following words on the label:

Danger	Poisonous	Volatile	Combustible	Caustic
Explosive	Warning	Corrosive	Flammable	Caution

- Try to keep products in original containers and always keep them well-labeled. If the product must be transferred to smaller containers, use the proper size funnel and avoid spills. Label all containers.
- Labels can fall off with weathering. To prevent, cover with transparent tape. To re-label, use a metal tag attached to the container or use a stencil and spray paint.
- Do not mix chemical substances unless recommended by the manufacturer.
- Use in well-ventilated areas. Protect skin, eyes, nose, and mouth when necessary by wearing gloves, respirator, or other protective clothing.
- Keep corrosive liquids away from flammable liquids.
- Look for nontoxic or less toxic options (check with the headquarters hazardous materials specialists in the Environmental Branch, or the district or headquarters materials engineers)
- Use all of the product before disposing of the container.

8.1.7 BMP C1.70 — Equipment Washing

Thinners or solvents should *not* be discharged into the sanitary or storm sewer systems when cleaning large machine parts where discharge of water is required. Use alternative methods for cleaning larger equipment parts such as high pressure, high temperature water washes, or steam cleaning.

Equipment washing detergents can be used and wash water discharged into the sanitary system if grit is removed from the solution first. The water discharged into the sewer must not exceed the discharge limits set by the local sewer authority.

Small parts can be cleaned with degreasing solvents which are reused after filtering or recycled. These solvents should *not* be discharged into any sewer. Further information is available from WSDOT hazardous materials specialists.

8.1.8 BMP C1.80 — Spill Control Planning and Cleanup

Contractors will be developing and implementing a spill control plan as part of their addendum to Temporary Erosion and Sediment Control Plans, if appropriate for the construction site involved. These spill control plans will identify persons responsible for implementing the plan if a spill of a dangerous or hazardous waste should occur. Any spill that occurs, regardless of the size and/or type of spill, should be reported to the following agencies:

- If the spill of a hazardous substance could reach surface waters, the following agencies must be notified (there are fines for failing to notify):
- Locally, notify the regional Department of Ecology offices:

  Northwest Region — Redmond (206) 649-7000 (24-hour)

  Southwest Region — Olympia (360) 753-2353 (24-hour)

  Central Region — Yakima (509) 575-2490 (24-hour)

  Eastern Region — Spokane (509) 456-2926 (24-hour)

  Or call the state of Washington Emergency Management Division, 24-hour emergency number: (800) 258-5990
- Within the city of Bellevue: Storm & Surface Water Utility (206) 455-7846 (24-hour)
- For EPA and Coast Guard Reporting: National Response Center (800) 424-8802

When reporting a spill, the following information must be provided:

- Reporting Party
- Material Released
- Concentration
- Contact Phone Number(s)
- Resource Damages (e.g., dead fish)
- Location
- Responsible Party
- Quantity of Spill
- Cleanup Status

Some of the important components of a spill control plan are:

- Establish who to notify in the event of a spill, particularly if it is hazardous.
- Provide specific cleanup instructions for different products handled on-site.
- Assign a person to be in charge of cleanup assistance.
- Prepare spill containment and cleanup lists that are easy to find and use.
- Post a summary of the cleanup plan at appropriate locations.
- If a spill occurs, demobilize it as quickly as possible.
- If there is a chance that the spill could enter a storm drain or sewer, plug the inlet and turn off or divert any incoming water.
- Cover the spill with absorbent material such as kitty litter or sawdust. Do not use straw. Dispose of the used absorbent per Ecology or manufacturer's instructions. If the spill is flammable, dispose of as directed by the local fire marshal.
- Keep the area well ventilated.

8.1.9 BMP C1.90 — Treatment and Disposal of Contaminated Soils

Contaminated ground water or soil may be encountered during earthwork activities or caused by the spill or leak of a hazardous product. The contaminant may be known or unknown. Trained personnel may need to conduct field investigations, sampling or laboratory tests to determine the cause and extent of the contamination, the pollutant(s) involved, and the cleanup and disposal options.

Procedures contained in the *Implementing Agreement Between the Department of Ecology and the Department of Transportation Concerning Hazardous Waste Management*, effective April 1, 1993, shall be followed if contaminated soils are encountered or caused at a construction site. District or headquarters hazardous materials specialists should be contacted immediately for the appropriate course of action. If an emergency exists due to on-going migration of the contamination, the situation should be treated as a spill.

8.1.10 BMP C2.00 — Concrete Trucks

The washout from a concrete truck should be disposed of into:

- A designated area which will later be backfilled: a slurry pit.
- An area where the concrete wash can harden, be broken up, and then disposed of as solid waste.
- A location which is not subject to surface water runoff, and more than 50 feet away from a storm drain, open ditch, or receiving water.

DO NOT dispose of truck washout water by dumping into:

- Sanitary sewer.
- Storm drain.
- Soil or pavement which carries stormwater runoff.

8-2 Erosion and Sediment Control BMPs

8-2.1 Temporary Cover Practices

8-2.1.1 BMP E1.10 — Temporary Seeding of Stripped Areas

Code: TS Symbol: ←TS→

Definition

The establishment of a temporary vegetative cover on disturbed areas by seeding with rapidly growing plants. This provides temporary soil stabilization to areas which would remain bare for more than seven days where permanent cover is not necessary or appropriate.

Conditions Where Practice Applies

- Permanent structures are to be installed or extensive regrading of the area will occur prior to the establishment of permanent vegetation.
- Areas which will not be subjected to heavy wear by construction traffic.
- Areas sloping up to 10 percent for 100 feet (30 m) or less (where temporary seeding is the only BMP used.

Advantages

- This is a relatively inexpensive form of erosion control but should only be used on sites awaiting permanent planting or grading. Those sites should have permanent measures used (see BMP E1.35, Permanent Seeding and Planting).
- Vegetation will not only prevent erosion from occurring, but will also trap sediment in runoff from other parts of the site.
- Temporary seeding offers fairly rapid protection to exposed areas.

Disadvantages/Problems

- Temporary seeding is only viable when there is a sufficient window in time for plants to grow and establish cover. During the establishment period the bare soil should be protected with mulch (see BMP E1.15) and/or plastic covering (see BMP E1.20).
- If sown on subsoil, growth may be poor unless heavily fertilized and limed. Because over-fertilization can cause pollution of stormwater runoff, other practices such as mulching (BMP E1.15) alone may be more appropriate. The potential for over-fertilization is an even worse problem in or near aquatic systems.
- Once seeded, areas cannot be used for heavy traffic.
- May require regular irrigation to flourish. Regular irrigation is not encouraged because of the expense and the potential for erosion in areas that are not regularly inspected. The use of low maintenance native species should be encouraged, and planting should be timed to minimize the need for irrigation.

Design Criteria

- Time of Planting — Planting should preferably be done between April 1 and June 30, and September 1 through October 31. If planting is done in the months of July and August, irrigation may be required. If planting is done between November 1 and March 31, mulching shall be required immediately after planting.
- Site Preparation — Before seeding, install needed surface runoff control measures such as gradient terraces, interceptor dike/swales, level spreaders, and sediment basins.
- Seedbed Preparation — The seedbed should be firm with a fairly fine surface. Perform all cultural operations across or at right angles to the slope. See BMP E1.45, Topsoiling, and BMP E2.35, Surface Roughening for more information on seedbed preparation. A minimum of 2 to 4 inches (50 to 100 mm) of tilled topsoil is required.
- Seeding — Seeding mixtures will vary depending on the exact location, soil type, slope, etc. Information on mixes may be obtained from the Environmental Section and the headquarters horticulturist.
- "Hydro-seeding" applications with approved seed-mulch-fertilizer mixtures may also be used.

Maintenance

- Seeding should be supplied with adequate moisture. Supply water as needed, especially in abnormally hot or dry weather or on adverse sites. Water application rates should be controlled to prevent runoff.
- Reseeding — Areas which fail to establish vegetative cover adequate to prevent erosion shall be re-seeded as soon as such areas are identified.

8-2.1.2 BMP E1.15 — Mulching and Matting

Code: MU Symbol: ← MU →

Definition

Application of plant residues or other suitable materials to the soil surface. This provides immediate protection to exposed soils during the period of short construction delays, or over winter months through the application of plant residues, or other suitable materials, to exposed soil areas.

Mulches also enhance plant establishment by conserving moisture and moderating soil temperatures. Mulch helps hold fertilizer, seed, and topsoil in place in the presence of wind, rain, and runoff and maintains moisture near the soil surface.

Conditions Where Practice Applies

- In areas which have been seeded either for temporary or permanent cover, mulching should immediately follow seeding.
- Areas which cannot be seeded because of the season, or are otherwise unfavorable for plant growth.

Advantages

- Mulching offers instant protection to exposed areas.
- Mulches conserve moisture and reduce the need for irrigation.
- Neither mulching nor matting require removal; seeds can grow through them unlike plastic coverings.

Disadvantages/Problems

- Care must be taken to apply mulch at the specified thickness, and on steep slopes mulch must be supplemented with netting.
- Thick mulches can reduce the soil temperature, delaying seed germination.

Organic Mulches

Straw — Straw is the mulch most commonly used in eastern Washington in conjunction with seeding. Its use is recommended where immediate protection is desired and preferably where the need for protection will be less than three months. The straw should come from wheat or oats, and may be spread by hand or machine. If the straw is not clean, weed growth can occur.

Straw can be windblown and must be anchored down. Common anchoring methods are:

1. Crimping, disking, rolling, or punching into the soil.
2. Covering with netting.
3. Spraying with a chemical or fiber binder (tackifier).
4. Keeping moist. Natural precipitation can often provide sufficient moisture.

Corn Stalks — These should be shredded into 4- to 6-inch (100 to 150 mm) lengths. Stalks decompose slowly and are resistant to windblow.

Wood Chips — Suitable for areas that will not be closely mowed, and around ornamental plantings. Chips decompose slowly and do not require tacking. They must be treated with 12 pounds nitrogen per ton (6 Kg per metric ton) to prevent nutrient deficiency in plants. Chips can be a very inexpensive mulch if they are obtained from trees cleared on the site. However, both wood and bark chips tend to wash down slopes of more than 6 percent and create problems by clogging inlet grates etc., and are therefore not preferred for use in those areas.

Wood Fiber — Wood fiber is the mulch most commonly used in western Washington in conjunction with seeding. It is used in hydro-seeding operations, applied as part of the slurry. These short cellulose fibers do not require tacking, although a tacking agent or soil binders are sometimes used with wood fiber. The longer the fiber length, the better the wood fiber will work in erosion control. This form of mulch does not provide sufficient protection to erodible soils to be used alone during the severe heat of summer or for late fall seedings. Wood fiber hydro-seed slurries may be used to tack straw mulch. This combination treatment is well suited for steep slopes, critical areas, and severe climate conditions.

Manure Mulches — Manure mulches should be well-aged and are not recommended for use near water bodies.

Chemical Mulches, Soil Binders, and Mats

The use of synthetic, spray-on materials (except tacking agents used with hydro-seeding) is not recommended. A major problem with their use is the creation of impervious surfaces and, possibly, adverse effects on water quality. Research has shown that they can cause more erosion when used than does bare exposed soil.

Nets and Mats — Used alone, netting does not retain soil moisture or modify soil temperature. It stabilizes the soil surface while grasses are being established, and is useful in grassed waterways and on slopes. Light netting may also be used to hold other mulches in place. There are some organic materials, such as jute and excelsior, that are available in the form of mats.

The most critical aspect of installing nets and mats is obtaining firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion occurs. It is important to use an adequate number of staples and to roll the material after laying it to ensure that the soil is protected.

Technique[2]	**Estimated Service Life (months)**	**Estimated Cost ($/(acre served) (6 months service)**
Straw (4 T/ac)	3	3,200
Straw (1.25 T/ac)	3	2,500
Straw (4 T/ac) manure-mulched, fertilized, seeded	6	2,400
Jute mat	6	3,700
Excelsior	6	3,600
Woven straw blanket	6	4,100
Synthetic fiber blanket	6	3,300
Wood fiber mulch (1.25 T/ac) fertilized, seeded	6	1,300
Wood fiber mulch (1.25 T/ac) with tackifier (50 gal/ac), fertilized, seeded	6	1,900
Wood fiber mulch (1.25 T/ac) with tackifier (90 gal/ac), fertilized, seeded	6	2,100
Wood fiber mulch (1.25 T/ac) with tackifier (120 gal/ac), fertilized, seeded	6	2,300
Chemical agent	6	2,100
Plastic sheeting	6	2,300

[2]The estimated cost of seeding where it was used is based on hydro-seeding (approximately $500/acre).

Summary of Estimated Service Lives and Costs
1988 Base

Figure 8-2.1

Design Criteria

- Site Preparation — Same as Temporary Seeding.
- Mulch Materials, Application Rates, and Specifications — See Figure 8-2.2
- Erosion blankets (nets and mats) may be used on level areas, on slopes up to 50 percent, and in waterways. Where soil is highly erodible, nets shall only be used in connection with an organic mulch such as straw and wood fiber. Jute nets shall be heavy, uniform cloth woven of single jute yarn, which if 36 to 48 inches (1 to 1.25 m) wide shall weigh an average of 1.2 lbs./linear yard (0.6 Kg per linear meter). It must be so applied that it is in complete contact with the soil. If it is not, erosion will occur beneath it. Netting shall be securely anchored to the soil with No. 11 gauge wire staples at least 6 inches (150 mm) long, with an overlap of 3 inches (75 mm).
- Excelsior blankets are considered protective mulches and may be used alone on erodible soils and during all times of year.
- See Figure 8-2.3 for orientation of netting and matting.

Maintenance

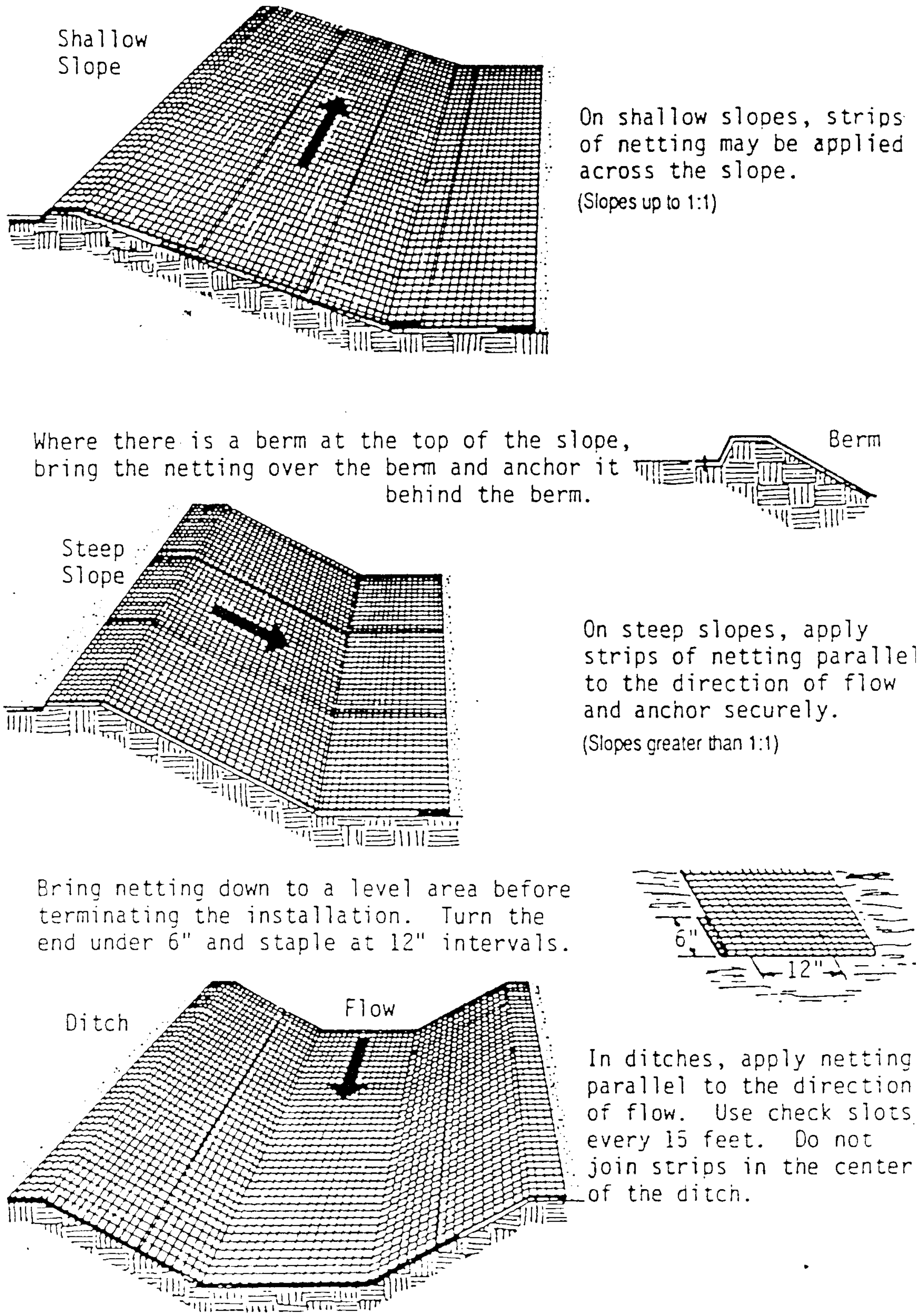
- Mulched areas should be checked periodically, especially following severe storms, when damaged areas of mulch or tie-down material should be repaired.
- All temporary erosion and sediment control measures that prohibit vegetative growth shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Mulch Material	**Quality Standards**	**Application Rates (/100m^2 (/hectare) /1000 ft^2 /acre**		**Depth of Application**	**Remarks[1]**
Gravel, slag or crushed stone	Washed, ¾ - 1½″ size 19.05 mm to 38.1 mm	9 yds^3 (7.5 m^3)		3 inches (80 mm)	Excellent mulch for short slopes and around woody plants and ornamentals. Use where subject to foot traffic. Approximately 2,000 lbs/yd^3 (1,200 Kgm^3).
Hay or straw	Air dried, free from unwanted seeds and coarse material	75 - 100 lbs. or 2 - 3 bales (40 - 50 Kg or 2 - 3 bales)	1½ - 2½ tons or 90 - 120 bales 3.5 - 6 metric tons or 225 - 300 bales	Minimum of 2 inches (50 mm)	Use where the mulching effect if to be maintained >3 months. Is subject to wind blowing unless kept moist or tacked down. Most common and widely used mulching material. Can be used in critical erosion areas.
Wood fiber, cellulose, (partially digested wood fibers)	Dyed green should not contain growth inhibiting factors	25 - 30 lbs. (13 - 15 Kg)	1,000 - 1,500 lbs. 1,100 - 1,700 Kg		If used on critical areas, double the normal application rate. Apply with hydromulcher. No tie-down required. Packaged in 100 pound (45 Kg) bags.

[1]All mulches will provide some degree of (1) erosion control, (2) moisture conservation, (3) weed control, and (4) reduction of soil crusting.

Guide to Mulch Materials, Rates, and Uses

Figure 8-2.2



Orientation of Netting and Matting

Figure 8-2.3

8-2.1.3 BMP E1.20 — Plastic Covering

Code: PC Symbol: ←PC→

Definition

The covering with plastic sheeting of bare areas which need immediate protection from erosion. This provides immediate temporary erosion protection to slopes and disturbed areas that cannot be covered by mulching, in particular during the specified seeding periods. Plastic is also used to protect disturbed areas which must be covered during short periods of inactivity to meet November 1 to March 31 cover requirements. Because of many disadvantages, plastic covering is the least preferred covering BMP.

Conditions Where Practice Applies

- Disturbed areas which require immediate erosion protection.

  Areas seeded during the time period from November 1 to March 1.

(Note: Plantings at this time require plastic covering for germination and protection from heavy rains.)

Advantages

- Plastic covering is a good method of protecting bare areas which need immediate cover and for winter plantings.
- May be relatively quickly and easily placed.

Disadvantages/Problems

- There can be problems with vandals and maintenance.
- The sheeting will result in rapid, 100 percent runoff which may cause serious erosion problems and/or flooding at the base of slopes unless the runoff is properly intercepted and safely conveyed by a collecting drain. This is strictly a temporary measure, so permanent stabilization is still required.
- The plastic may blow away if it is not adequately overlapped and anchored.
- Ultraviolet light can cause some types of plastic to become brittle and easily torn.
- Plastic must be disposed of at a landfill; it is not easily degradable in the environment.
- If plastic is left on too long during the spring it can severely burn any vegetation that has grown under it during cooler periods.

Design Criteria

- Plastic sheeting shall have a minimum thickness of 6 mil and meet the requirements of WSDOT/APWA Section 9-14.5.

- Covering shall be installed and maintained tightly in place by using sandbags or tires on ropes with a maximum 10-foot (3-m) grid spacing in all directions. All seams shall be taped or weighted down full length and there shall be at least a 1- to 2-foot (300 to 600 mm) overlap of all seams. Seams should then be rolled and staked or tied.
- Covering shall be installed immediately where required on areas seeded between November 1 to March 1, and remain until vegetation is firmly established.
- When the covering is used on unseeded slopes, it shall be left in place until the next seeding period.
- Sheeting should be toed in at the top of the slope to prevent surface flow beneath the plastic.
- Sheeting should be removed as soon as is possible once vegetation is well grown to prevent burning the vegetation through the plastic sheeting, which acts as a greenhouse.

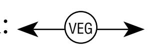
Maintenance

- Check regularly for rips and places where the plastic may be dislodged. Contact between the plastic and the ground should always be maintained. Re-anchor or replace the plastic as necessary.

8-2.2 Permanent Cover Practices

8-2.2.1 BMP E1.25 — Preserving Vegetation

Code: VEG

Symbol: 

Definition

Minimizing exposed soils and consequent erosion by clearing only where construction will occur.

Condition Where Practice Applies

- Vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on construction sites in wooded areas.

Advantages

Preserving vegetation will:

- Help reduce soil erosion.
- Reduce stormwater runoff.
- Beautify an area.
- Save money on landscaping costs.
- Provide areas for wildlife.
- Provide buffers and screens against noise.

- Moderate temperature changes and provide shade and cover habitat for surface waters and land. This is especially important where detention ponds drain to salmonid-bearing streams. Increases in water temperature tend to lower the dissolved oxygen available for aquatic life.

Disadvantages/Problems

Saving individual trees can be difficult, and older trees may become a safety hazard.

Design Criteria

Vegetation can be preserved in natural clumps or as individual trees, shrubs, and vines. The district or headquarters landscape architect or the headquarters horticulturist should be contacted when determining whether or not to remove vegetation.

The preservation of individual plants is more difficult because equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor, and the work involved.
- Is the tree or shrub a desirable plant? Is it shallow-rooted, do the roots seek water, or are insects and disease a problem? Shallow-rooted plants can cause problems in the establishment of lawns or ornamental plants. Water-seeking roots can block sewer and tile lines. Insects and diseases can make the plant undesirable. This is especially true with aphid on alder, oak, elm, and maple.
- Old and/or large plants do not generally adapt to changes in environment as readily as young plants of the same species. Usually, it is best to leave trees which are less than 40 years of age. Some of the hardwoods (red alder, cherry, etc.) mature at approximately 50 years of age. After maturity they rapidly decline in vigor. Conifers, after 40 years of age, may become a safety hazard due to the possibility of breakage or blowdown, especially where construction has left only a few scattered trees in an area that was formerly dense woods. While old large trees are sometimes desirable, the problem of later removal should be considered. It is expensive to cut a large tree and to remove the tree and stump from a developed area.
- Clearly flag or mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- Construction Equipment — This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Such injuries can be prevented by roping or fencing a buffer zone around plants to be saved prior to construction.
- Grade Changes — Changing the natural ground level will alter grades which affect the plant’s ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary. When there are major changes in grade, it may become necessary to

supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade.

The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches (300 mm) of the soil and cuts of only 2 to 3 inches (70 to 100 mm) can cause serious injury. To protect the roots, it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant.

Excavations — Protect trees and other plants when excavating for tile, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers.

If it is not possible to route the trench around plants to be saved, then the following should be observed:

- Cut as few roots as possible. When you have to cut — cut clean.
- Backfill the trench as soon as possible.
- Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.
- Some problems that can be encountered with a few specific trees are:
- Maple, dogwood, red alder, western hemlock, western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.
- The tip over hazard of Pacific silver fir is high while that of Western hemlock is moderate. The danger of tip over increases where dense stands have been thinned. Other species [unless they are on shallow, wet soils under 20 inches (0.5 m) deep] have a low tip over hazard.

Maintenance

- Inspect flagged areas regularly to make sure flagging has not been removed. If tree roots have been exposed or injured, recover and/or seal them.

8-2.2.2 BMP E1.30 — Buffer Zones

Code: BZ　　　　Symbol: ←BZ→

Definition

An undisturbed area or strip of natural vegetation or an established suitable planting that will provide a living filter to reduce soil erosion and runoff velocities.

Conditions Where Practice Applies

- Natural buffer zones are used along streams and other bodies of water that need protection from erosion and sedimentation. Vegetative buffer zones can be used to protect natural swales and incorporated into natural landscaping of an area.

Advantages

- Buffer zones provide critical habitat adjacent to streams and wetlands, as well as assist in controlling erosion, especially on unstable steep slopes. Buffers along streams and other water bodies also provide wildlife corridors, a protected area where wildlife can move from one place to another.
- Act as a visibility and noise screen.

Disadvantages/Problems

- Extensive buffers will increase project costs.

Design Criteria

- Preserving natural vegetation or plantings in clumps, blocks, or strips is generally the easiest and most successful method.
- Leave all unstable steep slopes in natural vegetation.
- Fence or flag clearing limits and keep all equipment and construction debris out of the natural areas.
- Keep all excavations outside the dripline of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage from burying and smothering.
- Vegetative buffer zones for streams, lakes, or other waterways should be a minimum of 100 feet (30 m) wide on each side with increases subject to other on-site sensitive conditions, existing vegetative conditions and erosion hazard potential. Contact the district Environmental Section for setback guidelines.

Maintenance

- Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed.

8-2.2.3 BMP E1.35 — Permanent Seeding and Planting

Code: PS

Symbol: ← PS →

Definition

The establishment of perennial vegetative cover on disturbed areas. This is done to prevent soil erosion by wind or water, and to improve wildlife habitat and site aesthetics.

Conditions Where Practice Applies

- Graded, final graded, or cleared areas where permanent vegetative cover is needed to stabilize the soil.
- Areas which will not be brought to final grade for a year or more.
- Vegetation-lined channels.
- Wet or dry ponds as required.

Advantages

- Well established grass and ground covers can give an aesthetically pleasing, finished look to a project.
- Once established, the vegetation will serve to prevent erosion and retard the velocity of runoff.

Disadvantages/Problems

- Vegetation and mulch cannot prevent soil slippage and erosion if soil is not inherently stable.
- May require regular irrigation to establish and maintain.

Design Criteria

- Vegetation cannot be expected to supply an erosion control cover and prevent slippage on a soil that is not stable due to its texture, structure, water movement, or excessive slope.
- Seeding should be done immediately after final shaping, except during the period of November 1 through March 1, when the site should be protected by mulching or plastic covering until the next seeding period.
- Permanent vegetation may be in the form of grass-type growth by seeding or sodding, or it may be trees or shrubs, or a combination of these. Establishing this cover may require the use of supplemental materials, such as mulch or jute netting (see BMP E1.15).
- Site Preparation — Install needed surface runoff control measures such as gradient terraces, berms, dikes, level spreaders, waterways, and sediment basins prior to seeding or planting.
- Seeding Grasses and Legumes — Seedbed Preparation — If infertile or coarse textured subsoil will be exposed during land shaping, it is best to stockpile topsoil and respread it over the finished slope at a minimum 2- to 6-inch (50 to 150 mm) depth and roll it to provide a firm seedbed. If construction fills have

left soil exposed with a loose, rough, or irregular surface, smooth with blade and roll. If cuts or construction equipment have left a tightly compacted surface, break with chisel plow or other suitable implement. Cultivation and raking should be done along the contour lines and compaction should be done perpendicular to the contour lines. The seedbed should be firm with a fairly fine surface.

- Soil Amendments — Rates will depend on-site characteristics and soil. Scatter amendments uniformly and work into the soil during seedbed preparation.
- Seeding — Seeding mixtures will vary depending on the exact location, soil type, slope, etc. Information on mixes may be obtained from the Environmental Section or the headquarters horticulturist.

Cover the seed with topsoil or mulch no deeper than 2 inches (50 mm). It is better to work topsoil into the upper soil layer rather than spread a layer of it directly onto the top of the native soil. “Hydro-seeding” applications with approved seed-mulch-fertilizer mixtures may also be used.

Do not under any circumstances use introduced, invasive plants like reed canarygrass (Phalaris arundinacea) or purple loosestrife (Lythrum salicaria). Using plants such as these will cause many more problems than they will ever solve.

Besides their erosion and sediment control values, trees and shrubs also provide natural beauty and wildlife benefits. When used for the latter, they are usually more effective when planted in clumps or blocks. These procedures should be followed:

1. Good quality planting stock should be used. Normally one or two-year-old deciduous seedlings, and three or four-year-old coniferous transplants, when properly produced and handled are adequate. Stock should be kept cool and moist from time of receipt and planted as soon as possible.
2. Competing vegetation should be controlled in the area where the plant or plants are to be placed.

Maintenance

Inspect seeded areas for failure and make necessary repairs and reseed immediately. Conduct or follow-up survey after one year and replace failed plants where necessary.

- If vegetative cover is inadequate to prevent rill erosion, overseed and fertilize in accordance with soil test results.
- If a stand has less than 40 percent cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand following seedbed preparation and seeding recommendations, omitting lime and fertilizer in the absence of soil test results. If the season prevents resowing, mulch or jute netting is an effective temporary cover.

8-2.2.4 BMP E1.40 — Sodding

Code: SO Symbol: ←SO→

Definition

Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod. This is done to establish permanent turf for immediate erosion protection or to stabilize drainageways where concentrated overland flow will occur.

Conditions Where Practice Applies

- Disturbed areas which require immediate vegetative cover.
- Waterways carrying intermittent flow, where immediate stabilization or aesthetics are factors and other locations which are particularly suited to stabilization with sod.

Advantages

- Sod will give immediate protection.
- Sod gives an immediate vegetative cover which is both effective in checking erosion and is aesthetically pleasing.
- Good sod has a high density of growth which is superior in protection to a recently seeded area.
- Sod can be placed at any time of the year provided that soil moisture is adequate and the ground is not frozen.

Disadvantages/Problems

- Sod is expensive.
- Sod is heavy and handling costs are high.
- Good quality sod, free from weed species, may be difficult to obtain.
- If laid in midsummer irrigation may be required. This also applies to very droughty sandy soils.
- Grass species in the sod may not be suitable for site conditions.
- If mowing is required, do not use grass sod on slopes steeper than 3:1 (use minimum maintenance ground covers).
- If not anchored or drained properly, sod will “roll up” in grassed waterways.

Design Criteria

- Shape and smooth the surface to final grade in accordance with the approved grading plan.
- Use of topsoil shall be in accordance with the requirements of Topsoiling (BMP E1.50).
- Add lime to reach a soil pH value of 6.5 (based on soil tests).
- Fertilize according to a soil test or, in the absence of a test, use available nitrogen, phosphorus and potash as prescribed for permanent seeding. Use fertilizers that are not highly soluble.

- Work lime and fertilizer into the soil 1 to 2 inches (25 to 50 mm) deep and smooth the surface.
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely in place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches (300 mm). Staple if on steep slopes.
- When sodding is carried out in alternating strips, or other patterns, seed the areas between the sod immediately after sodding.
- Sod should be free of weeds and be of uniform thickness [approximately 1 inch (25 mm)] and should have a dense root mat for mechanical strength.

Maintenance

- Inspect sodded areas regularly, especially after large storm events. Re-tack, re-sod, or re-seed as necessary.

8-2.2.5 BMP E1.45 — Topsoiling

Code: TO Symbol: ← TO →

While not a permanent cover practice in itself, topsoiling has been included in this section because it is an integral component of preparing permanent cover to those areas where there is an unsuitable soil surface for plant growth. Use of in-situ or imported topsoil is always preferable to planting in subsoil.

Definition

Preserving and using topsoil to enhance final site stabilization with vegetation. This provides a suitable growth medium for final site stabilization with vegetation.

Conditions Where Practice Applies

- Preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium, and the slopes are less than 2:1.
- Applicable to those areas with highly dense or impermeable soils or areas where planting is to be done in subsoil, where mulch and fertilizer alone would not provide a suitable growth medium.

Advantages

- Topsoil stockpiling ensures that a good growth medium will be available for establishing plant cover on graded areas. It has a high organic matter content and friable consistency, water holding capacity, and nutrient content.
- The stockpiles can be used as noise and view baffles during construction.

Disadvantages/Problems

- Stripping, stockpiling, and reapplying topsoil or importing topsoil may not always be cost-effective. It may also create an erosion problem if improperly secured.

- Unless carefully located, storage banks of topsoil may also obstruct site operations and therefore require double handling.
- Topsoiling can delay seeding or sodding operations, increasing exposure time of denuded areas.
- Most topsoil contains some weed seeds.

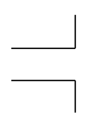
Design Criteria

- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural ground water recharge should be avoided.
- Stripping shall be confined to the immediate construction area. A 4- to 6-inch (100 to 150 mm) stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.
- Stockpiling of topsoil shall occur in the following manner:
  a. Side slopes of the stockpile shall not exceed 2:1.
  b. An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles.
  c. Erosion control seeding or covering with clear plastic or other mulching materials (see BMPs E1.10, E1.20) of stockpiles shall be completed within seven days of the formation of the stockpile.
- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.

8-2.3 Structural Erosion Control BMPS

8-2.3.1 BMP E2.10 — Stabilized Construction Entrance and Tire Wash

Code: CE

Symbol: 

Definition

A temporary stone-stabilized pad located at points of vehicular ingress and egress on a construction site. This reduces the amount of mud, dirt, rocks, etc., transported onto public roads by motor vehicles or runoff by constructing a stabilized pad of rock spalls at entrances to construction sites and washing of tires during egress.

Conditions Where Practice Applies

- Whenever traffic will be leaving a construction site and moving directly onto a public road or other paved areas.

Advantages

- Mud on vehicle tires is significantly reduced which avoids hazards caused by depositing mud on the public roadway.
- Sediment, which is otherwise contained on the construction site, does not enter stormwater runoff elsewhere.

Design Criteria

- Material should be quarry spalls (where feasible), 4 inches (100 mm) to 8 inches (200 mm) in size.
- The rock pad shall be at least 12 inches thick and 100 feet (30 m) in length for sites more than 1 acre; and may be reduced to 50 feet (15 m) in length for sites less than 1 acre.
- A filter fabric fence (see BMP E3.10) should be installed down-gradient from the construction entrance in order to contain any sediment-laden runoff from the entrance.
- Width shall be the full width of the vehicle ingress and egress area (minimum 20 feet or 6 m).
- Additional rock should be added periodically to maintain proper function of the pad.
- See Figure 8-2.4 for details.
- Tire washing should be done before the vehicle enters a paved street. Washing should be done on an area covered with crushed rock and the wash water should be drained to a sediment retention facility such as a sediment trap or basin.
- The volume of wash water produced by tire washing should be included when calculating the sediment trap or basin size.

Maintenance

- The entrance shall be maintained in a condition which will prevent tracking or flow of mud onto public rights of way. This may require periodic top dressing with 2-inch stone, as conditions demand, and repair and/or cleanout of any structures used to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

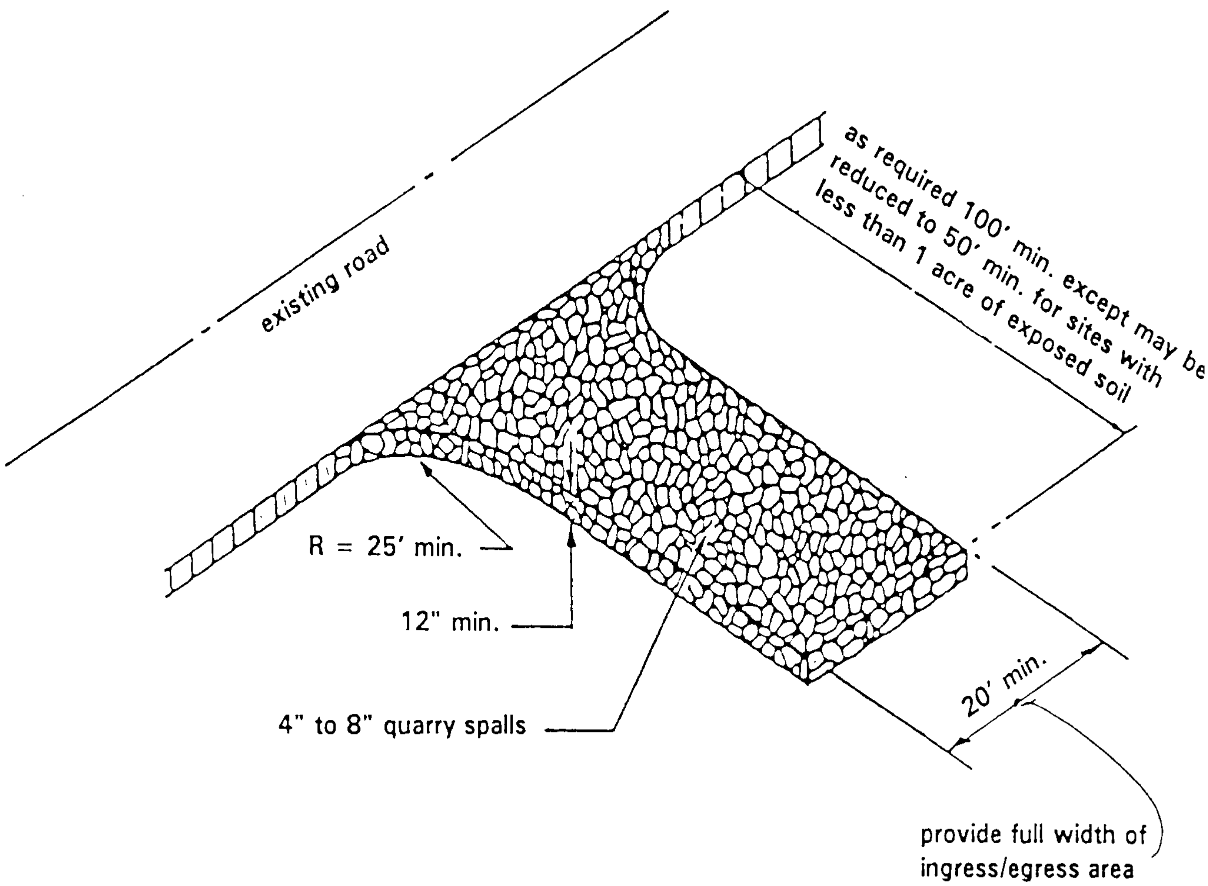
8-2.3.2 BMP E2.15 — Construction Road Stabilization

Code: CRS

Definition

The temporary stabilization with stone of access roads, parking areas, and other on-site vehicle transportation routes immediately after grading. This is done:

- To reduce erosion of temporary road beds by construction traffic during wet weather.
- To reduce the erosion and therefore regrading of permanent road beds between the time of initial grading and final stabilization.



Stabilized Construction Entrance

Figure 8-2.4

Conditions Where Practice Applies

- Wherever rock-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

Advantages

- Efficiently constructed road stabilization not only reduces on-site erosion but can significantly speed on-site work, avoid instances of immobilized machinery and delivery vehicles, and generally improve site efficiency and working conditions during adverse weather.

Disadvantages/Problems

- Measures on temporary roads must be cheap not only to install but also to demolish if they interfere with the eventual surface treatment of the area.
- Application of aggregate to construction roads may need to be made more than once during a construction period.

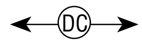
Design Criteria

- A 6-inch (150 mm) course of 2- to 4-inch (50 to 100 mm) crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or the completion of utility installation within the right of way. A 4-inch (100 mm) course of asphalt treated base (ATB) may be used in lieu of the crushed rock.
- Where feasible, alternative routes should be made for construction traffic; one for use in dry conditions, the other for wet conditions which incorporate the measures listed below.
- Temporary roads should follow the contour of the natural terrain to the maximum extent possible. Slope should not exceed 15 percent. Roadways should be carefully graded to drain transversely. Provide drainage swales on each side of the roadway in the case of a crowned section, or one side in the case of a super-elevated section.
- Installed inlets shall be protected to prevent sediment-laden water entering the drain sewer system (see BMP E3.30).
- Undisturbed buffer areas should be maintained at all stream crossings.
- Areas adjacent to culvert crossings and steep slopes should be seeded and mulched and/or covered.
- Dust control should be used when necessary (see BMP E2.20).

Maintenance

- Inspect stabilized areas regularly, especially after large storm events. Add crushed rock if necessary and restabilize any areas found to be eroding.

8-2.3.3 BMP E2.20 — Dust Control

Code: DC Symbol: 

Definition

Reducing surface and air movement of dust during land disturbing, demolition, and construction activities.

Conditions Where Practice Applies

- In areas (including roadways) subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventive measures are not taken.

Advantages

- A decrease in the amount of dust in the air will decrease the potential for accidents and respiratory problems.

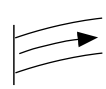
Disadvantages/Problems

- Use of water on-site to control dust emissions, particularly in areas where the soil is already compacted, can cause a runoff problem where there was not one.

Design Criteria

- Minimize the period of soil exposure through use of temporary ground cover and other temporary stabilization practices (see Seeding and Mulching, BMPs E1.10 and E1.15).
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, refer to Stabilized Construction Entrance (BMP E2.10).
- Spray exposed soil areas with approved dust palliative. Oil should not be used for dust suppression. Check with the district Construction Office to see which other dust palliatives may be used in the area.

8-2.3.4 BMP E2.25 — Pipe Slope Drains

Code: PSD Symbol: 

Definition

A pipe extending from the top to the bottom of a cut or fill slope and discharging into a stabilized water course or a sediment trapping device or onto a stabilization area. Pipe slope drains are used to carry concentrated runoff down steep slopes without causing gullies, channel erosion, or saturation of slide-prone soils.

Conditions Where Practice Applies

- Where a temporary (or permanent) measure is needed for conveying runoff down a slope without causing erosion.

Advantages

- Slope drains provide an effective method of conveying water safely down steep slopes.

Disadvantages/Problems

- Care must be taken to correctly locate drains and not underdesign them. Also, when clearing takes place prior to installing these drains, care must be taken to revegetate the entire easement area, otherwise erosion tends to occur beneath the pipeline, resulting in gully formation.

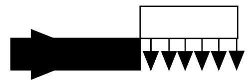
Design Criteria

- The capacity for temporary drains shall be sufficient to handle a 10-year flow. This may be computed using the conveyance design method as dicussed in Chapter 3. Permanent pipe slope drains shall be sized as described in the WSDOT *Hydraulics Manual*.
- The entrance shall consist of a standard flared end section for culverts 12 inches (300 mm) and larger. The slope of the entrance shall be at least 3 percent.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together and have gasketed watertight fittings, and be securely anchored into the soil.
- Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1 foot (300 mm) higher at all points than the top of the inlet pipe.
- The area below the outlet must be stabilized with a riprap apron.
- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.

Maintenance

- Check inlet and outlet points regularly, especially after heavy storms. The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags. The outlet point should be free of erosion and installed with appropriate outlet protection.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-2.3.5 BMP E2.50 — Level Spreader

Code: LS Symbol: 

Definition

A temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope. This converts concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

Condition Where Practice Applies

- To be constructed on undisturbed areas that are stabilized by existing vegetation and where concentrated flows are anticipated to occur at 0 percent grade.

Advantages

- Level spreaders disperse the energy of concentrated flows, reducing erosion potential and encouraging sedimentation.

Disadvantages/Problems

- If the level spreader has any low points, flow tends to concentrate there. This concentrated flow can create channels and cause erosion. If the spreader serves as an entrance to a water quality treatment system, short-circuiting of the forebay may happen and the system will be less effective in removing sediment and particulate pollutants.

Design Criteria

- The grade of the channel for the last 20 feet (6 m) of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- A 6-inch (150 mm) high gravel berm placed across the level lip shall consist of washed crushed rock, 2 to 4 inch (50 to 100 mm) or $^{3}/_{4}$ inch (1.91 cm) to $1^{1}/_{2}$ inch (19 to 38 mm) size.
- The spreader length will be determined by estimating the 25-year flow and selecting the appropriate length from the following table:

Q25, in CFS	(m^3/sec)	Min. Length, in Feet (m)
0-0.1	(0-0.028)	15 (4.5)
0.1-0.2	(0.028-0.057)	20 (6)
0.2-0.3	(0.057-0.085)	30 (9)
0.3-0.4	(0.085-0.11)	40 (12)

- When used with a biofiltration swale, the spreader length will be equal to the width of the swale.
- The width of the spreader should be at least 6 feet (1.8 m).

- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.
- The slope of the undisturbed outlet should not exceed 6 percent.

Maintenance

- The spreader should be inspected periodically to ensure that it is functioning correctly. The contractor should avoid the placement of any material on or prevent construction traffic across the structure. If the spreader is damaged by construction traffic, it shall be immediately repaired.

8-2.3.6 BMP E2.55 — Interceptor Dike and Swale

Code: IDS   Symbol: ← IDS →

Definition

A ridge of compacted soil or a swale with vegetative lining located at the top or base of a sloping disturbed area. This intercepts storm runoff from drainage areas above unprotected slopes and direct it to a stabilized outlet.

Conditions Where Practice Applies

- Where the volume and velocity of runoff from exposed or disturbed slopes must be reduced. When an interceptor dike/swale is placed above a disturbed slope, it reduces the volume of water reaching the disturbed area by intercepting runoff from above. When it is placed horizontally across a disturbed slope, it reduces the velocity of runoff flowing down the slope by reducing the distance that the runoff can flow directly downhill.

Advantages

- This BMP provides a practical, inexpensive method to divert runoff from erosive situations.

Disadvantages/Problems

- None.

Design Criteria

- Interceptor dikes shall meet the following criteria:

Top Width	2 feet (600 mm) minimum.
Height	18 inches (450 mm) minimum. Measured from upslope toe and at a compaction of 90 percent ASTM D698 standard proctor.
Side Slopes	3:1 or flatter.
Grade	Topography dependent, except that dike shall be limited to grades between 0.5 and 1.0 percent.

Horizontal Spacing of Interceptor Dikes

Slopes	<5%	=	300 feet (90 m)
Slopes	5-10%	=	200 feet (60 m)
Slopes	10-40%	=	100 feet (30 m)

Stabilization

Slopes	=	<5%	Seed and mulch applied within 5 days of dike construction (see BMP E1.10).
Slopes	=	5-40%	Dependent on runoff velocities and dike materials. Stabilization should be done immediately using either sod or riprap to avoid erosion.

Outlet	The upslope side of the dike shall provide positive drainage to the dike outlet. No erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.
Other	Minimize construction traffic over temporary dikes.

- Interceptor swales shall meet the following criteria:

Bottom Width	2 feet (600 mm) minimum; the bottom shall be level.
Depth	1 foot (300 mm) minimum.
Side Slope	3:1 or flatter.
Grade	Maximum 5 percent, with positive drainage to a suitable outlet (such as a sediment trap).
Stabilization	Seed as per BMP E1.10
	Temporary Seeding, or Riprap 12 inches (300 mm) thick pressed into the bank and extending at least 8 inches (200 mm) vertical from the bottom.

Swale Spacing

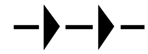
Slope of disturbed area:	<5%	=	300 feet (90 m)
	5-10%	=	200 feet (60 m)
	10-40%	=	100 feet (30 m)

Outlet	Level Spreader or Riprap to stabilized outlet/sedimentation pond.

Maintenance

- The measure should be inspected after every major storm and repairs made as necessary. Damage caused by construction traffic or other activity must be repaired before the end of each working day.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-2.3.7 BMP E2.60 — Check Dams

Code: CD Symbol: 

Definition

Small dams constructed across a swale or drainage ditch. This reduces the velocity of concentrated flows, reducing erosion of the swale or ditch.

Conditions Where Practice Applies

- Where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible and, therefore, velocity checks are required.
- In small open channels which drain 10 acres (4 Ha) or less. No check dams may be placed in streams (unless approved by the State Department of Fish and Wildlife as appropriate). Other permits may also be necessary.

Advantages

- Check dams not only prevent gully erosion from occurring before vegetation is established, but also cause a high proportion of the sediment load in runoff to settle out.
- In some cases, if carefully located and designed, these check dams can remain as permanent installations with very minor regrading, etc. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to precipitate further sediment coming off that site.

Disadvantages/Problems

- Because of their temporary nature, many of these measures are unsightly, and they should be removed or converted to permanent check dams before project completion.
- Removal may be a significant cost depending on the type of check dam installed.
- Temporary check dams are only suitable for a limited drainage area.

Design Criteria

- Check dams can be constructed of either rock, pea-gravel filled bags or logs. Provide a deep sump immediately upstream.
- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

- Rock check dams shall be constructed of appropriately sized rock. The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.
- Log check dams shall be constructed of 4 to 6-inch (100 to 150 mm) diameter logs. The logs shall be embedded into the soil at least 18 inches (450 mm).
- In the case of grass-lined ditches and swales, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

Maintenance

- Check dams shall be periodically monitored for performance and sediment accumulation producing rainfall. Sediment shall be removed when it reaches one half the sump depth.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-2.4 Sediment Retention

8-2.4.1 BMP E3.10 — Filter Fence

Code: FF   Symbol: *———*———*

Definition

A temporary sediment trap consisting of a filter fabric stretched across and attached to supporting posts and entrenched. The filter fence is constructed of stakes and synthetic filter fabric with a rigid wire fence backing where necessary for support.

Conditions Where Practice Applies

- Below disturbed areas where runoff may occur in the form of sheet and rill erosion; wherever runoff has the potential to impact downstream resources.
- Perpendicular to minor swales or ditch lines for contributing drainage areas up to one acre in size.

Advantages

- Downstream riparian and in stream habitat will not be damaged by sediment deposits originating from the development.
- Able to install at nearly any site where erosion is a problem.

Disadvantages/Problems

- Problems may arise from incorrect selection of pore size and/or improper installation.

- Filter fences should not be constructed in streams or used in V-shaped ditches. They are not an adequate method of runoff control for anything deeper than sheet or overland flow.

Design Criteria

- Maximum slope steepness (perpendicular to fence) is 1.5:1.
- Maximum sheet flow path length to the fence is 100 feet (30.5 m) for slopes between 1.5:1 and 3:1, 150 feet (45.7 m) for slopes between 3:1 and 6:1, and 200 feet (61.0 m) for slopes less steep than 6:1.
- Maximum apparent opening size (AOS) for slit film filter fabric is 0.60 mm (#30 sieve). All other filter material shall have a maximum AOS of 0.30 mm (#50 sieve). The minimum AOS for all filter fabrics is 0.15 mm (#100 sieve).
- The minimum permitivity is 0.05 sec^{-1}.
- The minimum grab tensile strength in machine and cross machine directions shall be 200 lbs. (900 N) for fabric that is unsupported between posts and 100 lbs. (450 N) for fabric that is supported with a wire or polymeric mesh. The maximum grab failure strain in machine direction shall be 30 percent for fabric that is unsupported between posts. There is no strain requirement for fabric that is supported between posts.
- The filter fabric shall have a service life of six months. To achieve this, the minimum strength retained after 500 hours in a weatherometer must be 70 percent.
- Fence backup support, if used, shall consist of 14 gage steel wire with a mesh spacing of 2 inches (50 mm) or a prefabricated polymeric mesh with support capabilities equivalent to the wire fencing. The polymeric mesh must be as resistant to ultraviolet radiation as the fabric that it supports.
- The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, they can be formed by folding the fabric from each section over on itself several times and firmly attaching the folded seam to the fence post. Any joints must be able to with stand the expected loading on the fabric.
- Support posts shall be spaced a maximum of 8 feet (2.4 m) apart and driven securely into the ground a minimum of 24 inches (600 mm) where physically possible. Support posts shall be either wood or steel. Wood posts shall have minimum dimensions of 1.5 inches (35 mm) by 1.5 inches (35 mm). Steel posts shall consist of either size No. 6 or larger rebar or ASTM A 120 steel pipe with a minimum diameter of 0.75 inches (20 mm).
- The minimum height of the filter fabric above the ground line is 30 inches (75 mm).
- A trench shall be excavated approximately 4 inches (100 mm) wide and 6 inches (150 mm) deep along the line of posts and upslope from the fence line. A minimum of 6 inches (150 mm) of filter fabric must extend into the trench. After placing the fabric, the trench must be backfilled and the soil tamped. When wire or plastic mesh support is used, the mesh shall be buried in the trench a minimum of 3 inches (75 mm).

- The fabric shall be attached on the upslope side of the posts and support system with staples, wire, or in accordance with the manufacturer's recommendations. Silt fence backup support for the material in the form of a wire or plastic grid is optional, depending on the properties of the material selected. If wire or plastic backup grid is used, the grid material shall be fastened securely to the upslope of the posts with the fabric being upslope of the grid backup support.
- Filter fences should only be placed where they will be beneficial, along the downhill end of an exposed slope where erosion is a potential problem. The ends of the fence shall turn upslope (run parallel to the slope) for a distance great enough to allow 30 inches (750 mm) of ponding depth behind the fence line that is perpendicular to the slope. For exposed slopes immediately adjacent to sensitive receiving waters, two rows of filter fence may be required to provide additional protection.
- Filter fences shall be removed when the upslope area has been permanently stabilized. Retained sediment must be removed and properly disposed of, or mulched and seeded.

Maintenance

- Inspect immediately after heavy rainfall, and regularly during prolonged rainfall. Repair as necessary.
- Sediment must be removed when it reaches approximately $^{1}/_{3}$ the height of the fence, especially if heavy rains are expected.
- Any sediment deposits remaining in place after the filter fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-2.4.2 BMP E3.15 — Straw Bale Barrier

Code: STB Symbol:

Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales. Straw bale barriers intercept and detain small amounts of sediment from disturbed areas to prevent sediment from leaving the site.

Conditions Where Practice Applies

- Below disturbed areas subject to sheet and rill erosion.
- Where the size of the drainage area is no greater than $^{1}/_{4}$ acre per 100 feet (1,000 m^2 per 30 m) of barrier length, the maximum slope length behind the barrier is 200 feet (61 m), and the maximum slope gradient behind the barrier is 50 percent (2:1).

- In minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres (0.8 Ha).
- Where effectiveness is required for less than three months.

Advantages

- When properly used, straw bale barriers are an inexpensive method of sediment control.

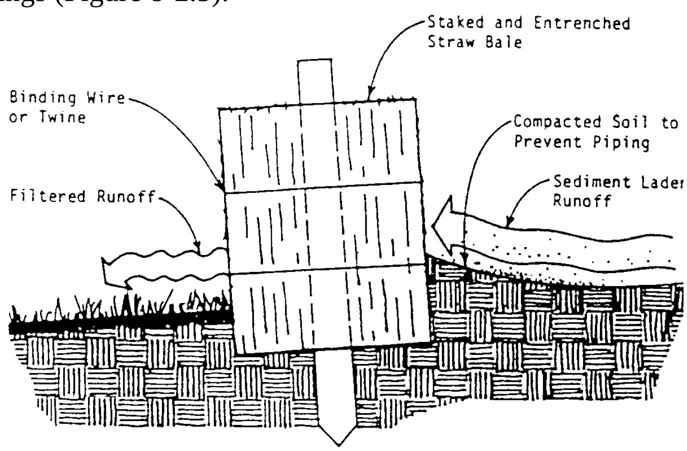
Disadvantages/Problems

- Straw bale barriers are easy to misuse and can become contributors to a sediment problem instead of a solution.
- It is difficult to tell if bales are securely seated and snug against each other.

Design Criteria

- A formal design is not required.
- Sheet Flow Applications

1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.
2. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings (Figure 8-2.5).



Cross-Section of a Properly Installed Straw Bale Barrier

Figure 8-2.5

3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches (100 mm). The trench must be deep enough to remove all grass and other material which might allow underflow. After the bales are staked and chinked (filled by wedging), the excavated soil shall be back-filled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches (100 mm) against the uphill side of the barrier (Figure 8-2.5).

4. Each bale shall be securely anchored by at least two stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or re-bars shall be driven deep enough into the ground to securely anchor the bales. Stakes should not extend above the bales but instead should be driven in flush with the top of the bale for safety reasons.
5. The gaps between the bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency. Wedging must be done carefully in order not to separate the bales.
6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.
7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

- Channel Flow Applications

1. Bales shall be placed in a single row, lengthwise, oriented perpendicular to the contour, with ends of adjacent bales tightly abutting one another.
2. The remaining steps for installing a straw bale barrier for sheet flow applications apply here, with the following addition.
3. The barrier shall be extended to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale to assure that sediment-laden runoff will flow either through or over the barrier but not around it.

Maintenance

- Straw bale barriers shall be inspected after each runoff-producing rainfall and regularly during prolonged rainfall.
- Close attention shall be paid to the repair of damaged bales, end runs, and undercutting beneath bales.
- Necessary repairs to barriers or replacement of bales shall be accomplished promptly.
- Sediment deposits should be removed when the level of deposition reaches approximately one-half the height of the barrier.
- Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-2.4.3 BMP E3.20 — Brush Barrier

Code: BB Symbol:

Definition

A temporary sediment barrier constructed at the perimeter of a disturbed area from residue materials available from clearing and grubbing on-site. Brush barriers intercept and retain sediment from disturbed areas.

Conditions Where Practice Applies

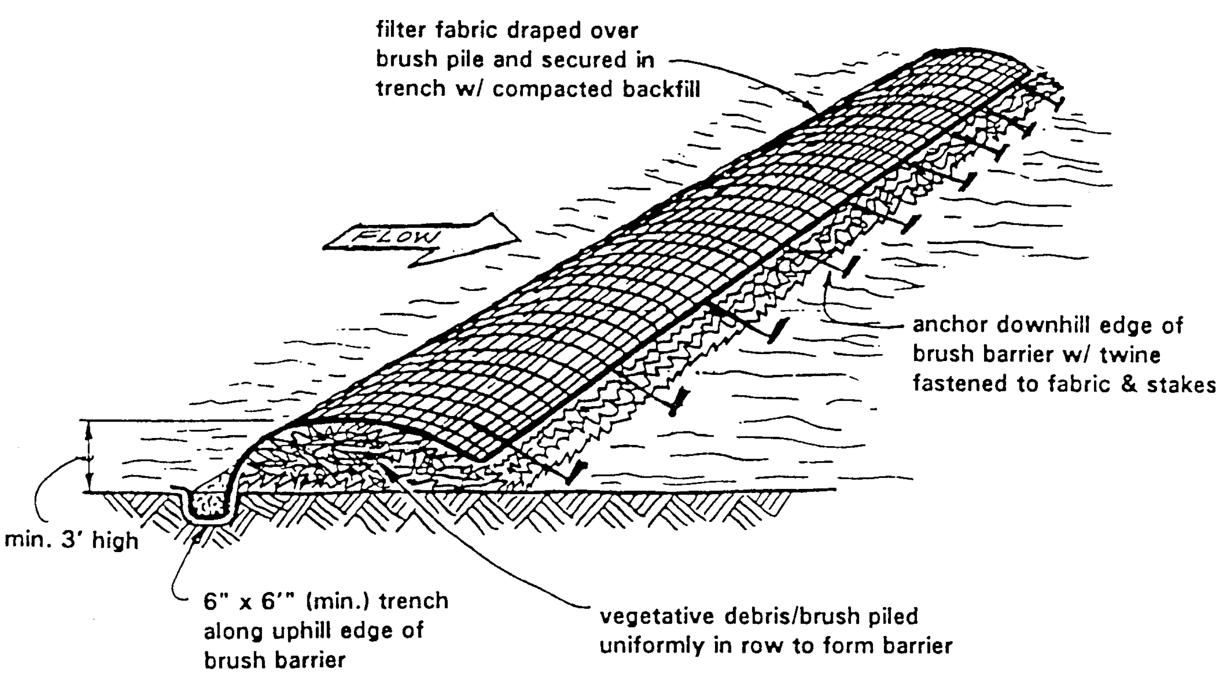
- Below disturbed areas of less than one quarter acre that are subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier.

Advantages

- Brush barriers can often be constructed using materials found on-site.

Design Criteria

- Height 3 feet (1 m) (minimum) to 5 feet (1.5 m) (maximum).
- Width 5 feet (1.5 m) at base (minimum) to 15 feet (4.5 m) (maximum).
- Filter fence anchored over the berm will enhance its filtration capacity.
- Further design details are illustrated in Figure 8-2.6.



Brush Barrier

Figure 8-2.6

Maintenance

- Brush barriers generally require little maintenance, unless there are very heavy deposits of sediment. Occasionally, tearing of the fabric may occur.
- When the barrier is no longer needed the fabric can be removed to allow natural establishment of vegetation within the barrier. Over time the barrier will rot.

8-2.4.4 BMP E3.25 — Gravel Filter Berm

Code: GFB Symbol: GFB

Definition

A gravel berm constructed on traffic areas within a construction site. Gravel filter berms retain sediment from traffic areas.

Conditions Where Practice Applies

- Where a temporary measure is needed to retain sediment in traffic areas on construction sites.

Advantages

- This is a very efficient method of sediment removal.

Disadvantages/Problems

- This BMP is more expensive to install than are other BMPs which use materials found on-site.

Design Criteria

- Berm material shall be to 3 inches (75 mm) in size, washed, well-graded gravel or crushed rock with less than 5 percent fines.
- Spacing of berms:

  Every 300 feet (90 m) on slopes less than 5 percent.

  Every 200 feet (60 m) on slopes between 5 and 10 percent.

  Every 100 feet (30 m) on slopes greater than 10 percent.
- Berm dimensions:

  1 foot (300 mm) high with 3:1 side slopes

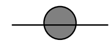
  8 linear feet (2.4 m) per 1 cfs (0.028 m^3/sec) runoff based on the 10-year storm.

Maintenance

- Regular inspection is required; sediment shall be removed and filter material replaced as needed.

8-2.4.5 BMP E3.30 — Storm Drain Inlet Protection

Code: IP

Symbol: 

Definition

A sediment filter or an excavated impounding area around a storm drain, drop inlet, or curb inlet. This prevents sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

Conditions Where Practice Applies

- Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions:

  a. Filter Fabric Fence — Applicable where the inlet drains a relatively small [less than 1 acre (0.40 Ha)] flat area (less than 5 percent slope). Do not place fabric under grate as the collected sediment may fall into the drain when the fabric is retrieved. This practice cannot easily be used where the area is paved because of the need for driving stakes to hold the material.

  b. Block and Gravel Filter — Applicable where heavy flows [greater than 0.5 cfs (0.014 m^3/sec)] are expected.

  c. Gravel and Wire Mesh Filter — Applicable where flows greater than 0.5 cfs (0.014 m^3/sec) are expected and construction traffic may occur over the inlet.

Advantages

- Inlet protection prevents sediment from entering the storm drain system and clogging it.

Disadvantages/Problems

- Sediment removal may be difficult, especially under high flow conditions.

Design Criteria

- Grates and spaces of all inlets should be secured to prevent seepage of sediment-laden water.
- All inlet protection measures should include sediment sumps of 1 to 2 feet (300 to 600 mm) in depth, with 2:1 side slopes.
- Installation procedure for filter fabric fence:

  a. Place 2-inch by 2-inch (50 by 50 mm) wooden stakes around the perimeter of the inlet a maximum of 3 feet (1 m) apart and drive them into the ground. The stakes must be at least 3 feet (1 m) long.

  b. Excavate a trench approximately 4 inches (100 mm) wide and 6 inches (150 mm) deep around the outside perimeter of the stakes.

c. Staple the filter fabric (for materials and specifications, see BMP E3.10, Filter Fence) to wooden stakes so that 6 inches of the fabric extends out and can be formed into the trench. Use heavy-duty wire staples at least $^1/_2$ inch (12 mm) in length.

d. Backfill the trench with $^3/_4$ inch (20 mm) or less washed gravel all the way around.

- Installation procedure for block and gravel filter:

a. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot (300 mm) beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with $^1/_2$-inch openings. If more than one strip is necessary, overlap the strips. Place filter fabric over the wire mesh.

b. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward, not upward. The ends of adjacent blocks should abut. The height of the barrier can be varied, depending on design needs, by stacking combinations of blocks that are 4 inches (100 mm), 8 inches (200 mm), and 12 inches (300 mm) wide. The row of blocks should be at least 12 inches (300 mm), but no greater than 24 inches (600 mm) high.

c. Place wire mesh over the outside vertical face (open end) of the concrete blocks to prevent stone from being washed through the blocks. Use hardware cloth or comparable wire mesh with one half inch openings.

d. Pile washed stone against the wire mesh to the top of the blocks. Use $^3/_4$- to 3-inch (20 to 75 mm) gravel.

- Installation procedure for gravel and wire mesh filter:

a. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot (300 mm) beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with $^1/_2$-inch (12 mm) openings. If more than one strip of mesh is necessary, overlap the strips. Place filter fabric over wire mesh.

b. Extend the filter fence/wire mesh beyond the inlet opening at least 18 inches (450 mm) on all sides. Place 3-inch (75 mm) gravel over the filter fabric/wire mesh. The depth of the gravel should be at least 12 inches (300 mm) over the entire inlet opening.

Maintenance

- For systems using filter fabric: Inspections should be made on a regular basis, especially after large storm events. If the fabric becomes clogged, it should be replaced. Sediment should be removed when it reaches approximately one-half the height of the fence. If a sump is used, sediment should be removed when it fills approximately one half the depth of the hole.
- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-2.4.6 BMP E3.35 — Sediment Trap

Code: ST Symbol:

Definition

A small temporary ponding area, with a gravel outlet, formed by excavation and/or by constructing an earthen embankment. A sediment trap is used to collect and store sediment from sites cleared and/or graded during construction. The trap is a temporary measure (with a design life of approximately six months) and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Conditions Where Practice Applies

- Proposed construction sites where the tributary drainage area is less than 3 acres (1.2 Ha).

Advantages

- Downstream riparian properties will not be damaged by sediment deposits originating from that development.
- Sediment deposits downstream will not reduce the capacity of the stream channel.
- Sediment will not cause the clogging of downstream impoundments and other facilities.

Disadvantages/Problems

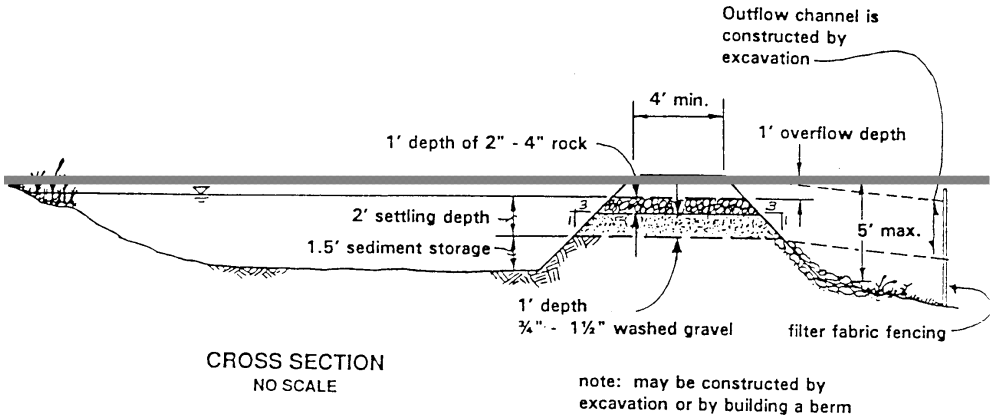
- Serves only limited areas.
- Sediment traps (and ponds, see BMP E3.40) are only practically effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

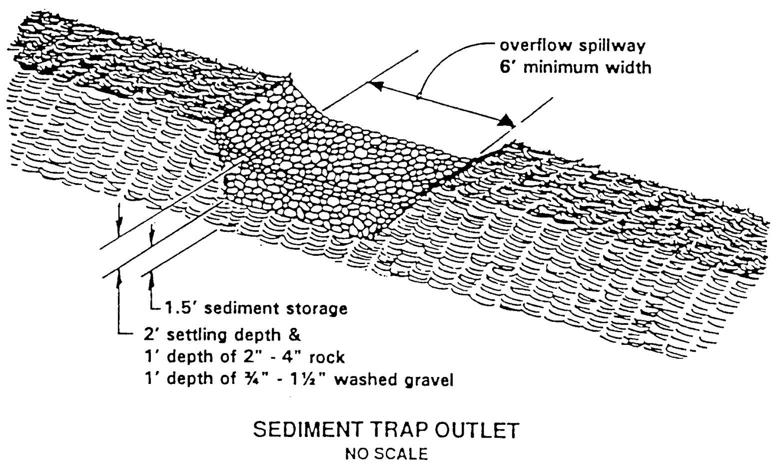
Design Criteria

The sediment trap may be formed completely by excavation or by construction of a compacted embankment. It shall have a 1.5 foot (0.45 m) deep sump for sediment storage. The outlet shall be a weir/spillway section, with the area below the weir acting as a filter for sediment and the upper area as the overflow spillway depth.

- See Figure 8-2.7 for details.
- The temporary sediment trap volume can be found by computing the detention volume required for the 2-year storm using one of the approved methods found in Chapter 3. Side slopes should not exceed 3:1. After

determining the necessary volume, size the trap by adding an additional $1^1/_2$ feet (450 mm) for sediment accumulation to the volume computed using the 2-year storm.





Sediment Trap

Figure 8-2.7

- To complete the design of the temporary sediment trap:
- A 3:1 aspect ratio between the trap length and width of the trap is desirable. Length is defined as the average distance from the inlet to the outlet of the trap. This ratio is included in the computations for the surface area at the interface between the settling zone and sediment storage volume.
- Determine the bottom and top surface area of the sediment storage volume to be provided using $1^1/_2$ feet (450 mm) in depth for sediment storage and 3:1 side slope from the bottom of the trap. Note the trap bottom should be level.
- Determine the total trap dimensions by adding the depth required for the 2-year, 24-hour design storm above the surface of the sediment storage volume, while not exceeding 3:1 side slopes.

Maintenance

- The key to having a functional sediment trap is continual monitoring and regular maintenance. The size of the trap is less important to its effectiveness than is regular sediment removal. Sediment should be removed from the trap when it reaches approximately one foot (300 mm) in depth [assuming a 1 1/2 foot (450 m) sediment accumulation depth]. Regular inspections should be done and additional inspections made after each large runoff-producing storm.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-2.4.7 BMP E3.40 — Temporary Sediment Pond

Code: SB

Definition

A temporary basin with a controlled stormwater release structure formed by constructing an embankment of compacted soil across a drainageway, or other suitable locations. It is used to collect and store sediment from sites cleared and/or graded during construction or for extended periods of time before re-establishment of permanent vegetation and/or construction of structures. The basin is a temporary measure (with a design life less than one year) and is to be maintained until the site area is permanently protected against erosion.

Conditions Where Practice Applies

- Proposed construction sites where the tributary drainage is less than 10 acres (4 Ha).

Advantages

- Because of additional detention time, sediment ponds may be capable of trapping smaller sediment particles than traps. However, they are most effective when used in conjunction with other BMPs such as seeding or mulching.

Disadvantages/Problems

- Ponds may become an “attractive nuisance” and care must be taken to adhere to all safety practices.
- Sediment ponds are only practically effective in removing sediment down to about the medium silt size fraction. Sediment-laden runoff with smaller size fractions (fine silt and clay) will pass through untreated emphasizing the need to control erosion to the maximum extent first.

Design Criteria

The sediment pond may be formed by partial excavation and/or by construction of a compacted embankment. It may have one or more inflow points carrying polluted runoff. Baffles to spread the flow throughout the basin should be included. A securely anchored riser pipe is the principal discharge mechanism along with an emergency overflow spillway. The riser pipe shall be solid with two 1-inch (25-mm) diameter dewatering holes located at the top of the sediment storage volume on opposite sides of the riser pipe. Outlet protection is provided to reduce erosion at the pipe outlet.

- The sediment pond volume is the sum of the sediment storage volume [3 feet (1 m) in depth] plus a settling volume of not less than 2 feet (600 mm) in depth. The sediment depth is computed based on the basin surface area required to settle out the design particle at the design inflow rate.

Computing the Settling Zone Volume: The settling zone volume may be approximated by assuming a 2-foot (600 mm) depth above the sediment storage volume and extending the 3:1 side slopes as necessary, or by computing the precise volume as outlined below. The maximum settling zone depth shall be 4 feet (1.2 m).

a. Pond Surface Area

The settling zone volume is determined by the pond surface area which is computed using the following equation: (SA) = $1.2Q_{10} / V_{sed}$.

Where Q_{10} = design inflow based on the peak discharge from a 10-year, 24-hour duration design storm event from the tributary drainage area as computed using the methods described in Chapter 3.

V_{sed} = the settling velocity of the design soil particle. The design particle chosen is medium silt (0.02 mm). This has a settling velocity (V_{sed}) of 0.00096 ft/sec (2.9×10^{-4} m/sec). Note that for the relatively common sandy loam soils found in the Puget Sound basin, approximately 80 percent of the soil particles are larger than 0.02 mm. Thus, choosing a design particle size of 0.02 mm gives a theoretical trapping efficiency of approximately 80 percent. In practice, and for more finely textured soils, the trapping efficiency would be less. However, as a general rule, it will not be necessary to design for a particle of size less than 0.02 mm, especially since the surface area requirement increases dramatically for smaller particle sizes. For example, a design particle of 0.01 mm requires about three times the surface area of 0.02 mm. Note that choosing a V_{sed} of 0.00096 ft/sec (2.9×10^{-4} m/sec) equates to a surface area (SA) of 1,250 square feet per cfs (4,100 m^2 per m^3/sec) of inflow.

b. Settling depth (SD) should not be less than 2 feet (600 mm) and is also governed by the sediment storage volume surface area and relationship to the basin length (L). The basin length is defined as the average distance from the inlet to the outlet of the pond.

The ratio of L/SD should be less than 200.

The settling volume is therefore the surface area (SA) times the required settling depth.

To complete the design of the sediment pond:

Total sediment pond volume and dimension are determined as outlined below:

a. Determine pond geometry for the sediment storage volume calculated above using 3 feet (1 m) in depth and 3:1 side slopes from the bottom of the basin. Note, the basin bottom is level.

b. Extend the pond side slopes (at 3:1 maximum) as necessary to obtain the settling zone volume at 2-foot (600 mm) depth minimum or as determined above, 4-foot (1.2-m) maximum.

c. Adjust the geometry of the basin to effectively combine the settling zone volume and sediment storage volumes while preserving the depth and side slope criteria.

Provide baffles to prevent short-circuiting. A 6:1 aspect ratio between the basin length and width of the pond is desirable.

Maintenance

- Inspections should be made regularly, especially after large storm events. Sediment should be removed when it fills one half of the pond's total sediment storage area. The effectiveness of a sediment pond is based less on its size than on regular sediment removal.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

8-3 Water Quality BMPs

8-3.1 BMP RB.05 — Biofiltration Swale

Definition

Biofiltration is the simultaneous process of filtration, particle settling, adsorption, and biological uptake of pollutants in stormwater that occurs when runoff flows over and through vegetated areas. A biofiltration swale is a sloped, vegetated channel or ditch that provides both conveyance and water quality treatment to stormwater runoff. It does not provide stormwater quantity control but can convey runoff to BMPs designed for that purpose.

General Criteria

1. The swale should have a length of 200 feet (61.0 m). The maximum bottom width is 10 feet (3.1 m). The depth of flow must not exceed 4 inches (100 mm) during the 6-month storm.
2. The channel slope should be at least 1 percent and no greater than 5 percent.
3. The swale can be sized as both a treatment facility for the 6-month storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line."
4. The ideal cross-section of the swale should be a trapezoid. The side slopes should be no steeper than 3:1.
5. Roadside ditches should be regarded as significant potential biofiltration sites and should be utilized for this purpose whenever possible.

6. If flow is to be introduced through curb cuts, place pavement slightly above the biofilter elevation. Curb cuts should be at least 12 inches (300 mm) wide to prevent clogging.
7. Install low-flow biofiltration swales within ponds where sufficient land does not exist for both.
8. Biofilters must be vegetated in order to provide adequate treatment of runoff.
9. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. Consult the district or headquarters Landscape Section for specific vegetation selection recommendations.
10. Biofilters should generally not receive construction-stage runoff. If they do, presettling of sediments should be provided (see BMPs E3.35 and E3.40). Such biofilters should be evaluated for the need to remove sediments and restore vegetation following construction.
11. If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Design Procedure

1. Determine the peak flow rate to the biofilter from the 6-month 24 hour design storm.
2. Determine the slope of the biofilter. This will be somewhat dependent on where the biofilter is placed. The slope should be at least 1 percent and shall be no steeper than 5 percent. When slopes less than 2 percent are used, the need for underdrainage must be evaluated.
3. Select a swale shape. Trapezoidal is the most desirable shape; however, rectangular and triangular shapes can be used. The remainder of the design process assumes that a trapezoidal shape has been selected.
4. Use Manning's Equation to estimate the bottom width of the biofilter. Manning's Equation for English units is as follows:

$$Q = (1.486\ A\ R^{0.667}\ S^{0.5}) / n$$

Where: Q = flow (cfs)

A = cross sectional area of flow (ft^2)

R = hydraulic radius of flow cross section (ft)

S = longitudinal slope of biofilter (ft/ft)

n = Manning's roughness coefficient = 0.20 for typical biofilter

For a trapezoid, this equation cannot be directly solved for bottom width. However, for trapezoidal channels that are flowing very shallow the hydraulic radius can be set equal to the depth of flow. Using this assumption, the equation can be altered to:

$$b = ((0.135\ Q) / (y^{1.667}\ S^{0.5})) - zy$$

Where: y = depth of flow

z = the side slope of the biofilter in the form of z:1

Typically the depth of flow is selected to be 4 inches (100 mm). It can be set lower but doing so will increase the bottom width. Sometimes when the flowrate is very low the equation listed above will generate a negative value for b. Since it is not possible to have a negative bottom width, the bottom width should be set to 1 foot when this occurs.

Biofilters are limited to a maximum bottom width of 10 feet. If the required bottom width is greater than 10 feet, parallel biofilters should be used in conjunction with a device that splits the flow and directs the proper amount to each biofilter.

5. Calculate the cross sectional area of flow for the given channel using the calculated bottom width and the selected side slopes and depth.

6. Calculate the velocity of flow in the channel using:

$$V = Q / A$$

If V is less than or equal to 1 ft/sec, the biofilter will function correctly with the selected bottom width. Proceed to design step 7.

If V is greater than 1 ft/sec, the biofilter will not function correctly. Increase the bottom width, recalculate the depth using Manning's Equation and return to design step 5.

7. Select a location where a biofilter with the calculated width and a length of 200 feet (61 m) will fit. If a length of 200 feet (61 m) is not possible, the width of the biofilter must be increased so that the area of the biofilter is the same as if a 200 foot (61 m) length had been used.

8. Select a vegetation cover suitable for the site. Refer to the district or headquarters landscape architect or the headquarters horticulturist.

9. Determine the peak flow rate to the biofilter during the 100-year 24-hour storm. Using Manning's Equation, find the depth of flow (typically n = 0.04 during the 100-year flow). The depth of the channel shall be 1 foot (300 mm) deeper than the depth of flow.

Construction and Maintenance Criteria

1. Groomed biofilters planted in grasses shall be mowed during the summer to promote growth and pollutant uptake.

2. Remove sediments during summer months when they build up to 4 inches (100 mm) at any spot, cover biofilter vegetation, or otherwise interfere with biofilter operation. If the removal equipment leaves bare spots, reseed those spots.

3. Inspect biofilters periodically, especially after periods of heavy runoff. Remove sediments, fertilize, and reseed as necessary. Be careful to avoid introducing fertilizer to receiving waters or ground water.

4. Clean curb cuts when soil and vegetation buildup interferes with flow introduction.

5. Remove litter to keep biofilters free of external pollution.

8-3.2 BMP RB.10T — Vegetative Filter Strip

Definition

A vegetative filter strip is a facility that is designed to provide stormwater quality treatment of conventional pollutants but not nutrients. This BMP will not provide stormwater quantity control. The primary use of vegetative filter strips will be along rural roadways where sheet flow from the roadway will pass through the filter strip before entering a conveyance system or a quantity control facility. The vegetative filter strip is still in an interim phase of development. This BMP is acceptable for use on any project that meets the General Criteria listed below; however, the General Criteria may change in the near future as research projects and field tests involving this BMP are completed. Users of this manual that are not associated with WSDOT should contact Michelle Horn of the Department of Ecology's Water Quality Unit to verify the applicability of this BMP before using it in a project.

General Criteria

1. The width of a filter strip shall be 10 feet (3 m) with a transverse slope between 1 percent and 15 percent.
2. Filter strips may be placed 3 to 4 feet (1 to 1.25 m) from the edge of pavement, to accommodate a vegetation free zone.
3. Once stormwater has been treated by a filter strip, it shall be collected and conveyed to a stormwater quantity BMP.
4. Vegetative filter strips must not receive concentrated flow discharges.
5. A maximum of two lanes can contribute to a filter strip.
6. The roadway ADT is less than 30,000.
7. Vegetative filter strips should not be used on roadways with longitudinal slopes greater than 5 percent because of the difficulty in maintaining the necessary sheet flow conditions.
8. Vegetative filter strips should be constructed after other portions of the project are completed.

Design Procedure

Provide an area next to the roadway to use as a filter strip. The strip must run the length of the roadway to be treated and have a width of 10 feet (3 m) with a slope between 1 and 15 percent. The flow from the roadway must enter the filter strip as sheet flow.

Construction and Maintenance Criteria

1. Construct filter strips after completion of the highway project.
2. Groomed filter strips planted in grasses shall be mowed during the summer to promote growth.
3. Inspect filter strips periodically, especially after periods of heavy runoff. Remove sediments and reseed as necessary.

4. Remove litter to keep filter strips free of external pollution and ensure sheet flow through the filter strip.

8-3.3 BMP RD.05 — Wet Pond

Definition

A wet pond is a facility that treats stormwater for water quality by utilizing a permanent pool of water to remove conventional pollutants from runoff through sedimentation, biological uptake, and plant filtration. A wet pond may also be designed to provide stormwater quantity control through the use of a “live storage” area above the permanent pool.

General Criteria

1. Wet ponds shall be multi-celled with at least two cells, and preferably three. The cells should be approximately equal in size. The first cell should be 3-feet deep in order to effectively trap coarser sediments and reduce turbulence which can resuspend sediments. It should be easily accessible for maintenance purposes. The berm dividing the pond into cells shall have a 5-foot (1.5-m) minimum top width, a top elevation set 1 foot lower than the design water surface, maximum 3:1 side slopes, and a quarry spall and gravel filter “window” between the cells.
2. All facilities shall be a minimum of 20 feet (6 m) from any structure, right of way line, and any vegetative buffer, and 100 feet (30 m) from any septic tank/drain field. All facilities shall be a minimum of 50 feet (15 m) from any steep (greater than 15 percent) slope unless a geotechnical report has indicated that the steep slope will be stable.
3. Long, narrow, and irregularly shaped ponds are preferred, as these configurations are less prone to short-circuiting and tend to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. Irregularly shaped ponds may perform more effectively and will have a more natural appearance.
4. The pond bottom shall be level to facilitate sedimentation.
5. Interior side slopes up to the maximum water surface shall be no steeper than 3H:1V. Exterior side slopes shall be no steeper than 2H:1V. Slopes should be no steeper than 4H:1V if they are to be mowed.
6. Pond walls may be retaining walls, provided that a fence is provided along the top of the wall, and that at least 25 percent of the pond perimeter will be a vegetated soil slope of not greater than 3H:1V.
7. For berm embankments of 6 feet (1.8 m) or less (including 1 foot (300 mm) freeboard), the minimum top width shall be 6 feet (1.8 m) or as recommended by the engineer.
8. The toe of the exterior slope of pond berm embankment must be no closer than 5 feet (1.5 m) from the right of way.
9. The berm embankment shall be constructed in accordance with Section 2-03.3(14)C Method C of WSDOT *Standard Specifications*.

10. A “key” must be excavated that is equal to 50 percent of the berm embankment cross-sectional height and width (except on highly compacted till soils where the “key” minimum depth can be reduced to 1 foot (300 mm) of excavation into the till).
11. Anti-seepage collars must be placed on outflow pipes in berm embankments impounding water greater than 8 feet (2.5 m) in depth at the design water surface.
12. Exposed earth on the side slopes shall be sodded or seeded with the appropriate seed mixture as soon as is practicable. Establishment of protective vegetative cover shall be ensured with erosion protection and reseeded as necessary.
13. The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then baffles can be installed to increase the flow path and water residence time.
14. If a wet pond is used during construction, the pond should be cleaned before becoming a permanent erosion control fixture.
15. Detention facility design must take into consideration overflow. Overflow may result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.
16. Design with maintenance in mind. Good maintenance will be crucial to successful use of the impoundment. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance should be a basic consideration in design and in determination of first cost.

Design Procedure

1. Calculate the runoff hydrograph for the 6-month 24-hour design storm (see Chapter 3).
2. The wet pond shall be designed with a permanent pool volume equal to the runoff volume of the 6-month design storm. It is not necessary to vegetate the permanent pool, but establishment of a shallow marsh system can provide additional pollutant removal capabilities.
3. If the wet pond is not to be used for stormwater quantity control, then design an outlet such as a weir or an orifice that will pass the 100-year event through the pond. Place the invert of the outlet at the same elevation as the top of the dead storage volume. The flow leaving the wet pond will discharge either to a large receiving body or to a quantity control BMP.
4. If the wet pond is to be used for quantity control, estimate the volume needed above the dead storage volume. Base the estimate on the difference between the 100-year pre-project and 100-year post-project hydrographs.
5. Route the 2-year, 10-year, and 100-year post-project storms through the pond, one storm event at a time. An outlet device such as a weir or an orifice must be designed to match each release rate. WaterWorks can be used to design an orifice or analyze a given outlet structure.

6. Continue to alter the volume until the allowable release rates are not exceeded. After this is accomplished, the factor of safety must be applied (see Figure 2-6.2) and the design volume must be increased without increasing the depth to establish the final volume.
7. Identify an overflow route to be used in the event that the pond capacity is exceeded. This overflow route should be designed to meet Minimum Requirement No. 2 (Preservation of Natural Drainage Systems).

Construction and Maintenance Criteria

1. Roads in and around the pond shall be constructed according to standard WSDOT practices and meet the following criteria:
   - Maximum Grade: 15 percent to control structure, 20 percent into pond.
   - Provide 40-foot (12 m) minimum outside radius on the access road to the control structure and the turn around to the pond bottom.
   - Fence gates shall be provided for access roads at “straight” sections of road.
   - Access roads shall be 15 feet (4.5 m) in width.
   - Manhole and catch basin lids must be at either edge of an access road or pad and be at least 3 feet (1 m) from a property line.
2. Access shall be limited by a double-posted gate if a fence is required or by bollards. Bollards shall consist of two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.
3. Standing water removed during the maintenance operation may require disposal at an approved discharge location.
4. Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Sediment deposition should be continually monitored in the basin. Significant concentrations of heavy metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of these treatment facilities. Testing of sediment, especially near points of inflow, should be conducted regularly to determine the leaching potential and level of accumulation of hazardous material before disposal. Contact the district environmental staff for assistance.
5. Remove litter to keep the pond free of external pollution.
6. Check the pond for damage caused by erosion and restabilize areas where there is the potential for continued erosion.
7. Maintain pond shape and depth by removing accumulated sediments that exceed 10 percent of the designed pond depth.

8-3.4 BMP RD.06 — Nutrient Control Wet Pond

Definition

This BMP is similar to BMP RD.05 (Wet Pond) but also includes a shallow marsh area which provides additional removal of nutrients. The shallow marsh area is contained within the permanent pool of water. Stormwater quantity control can also be provided through this BMP by adding a "live storage" area above the permanent pool. This BMP should only be used when discharging to a documented nutrient sensitive water body.

General Criteria

1. Wet ponds shall be multi-celled with at least two cells, and preferably three. The cells should be approximately equal in size. The first cell should be easily accessible for maintenance purposes. The berm dividing the pond into cells shall have a 5-foot (1.5 m) minimum top width, a top elevation set one foot lower than the design water surface, maximum 3:1 side slopes, and a quarry spall and gravel filter "window" between the cells.
2. A portion of the pond shall be constructed as a shallow marsh area. Planting wetland associated plants in the marsh area is not required but is beneficial and recommended.
3. All facilities shall be a minimum of 20 feet (6 m) from any structure, right-of-way line, and any vegetative buffer required by the local government, and 100 feet (30 m) from any septic tank/drainfield. All facilities shall be a minimum of 50 feet (15 m) from any steep (greater than 15 percent) slope unless a geotechnical report has indicated that the steep slope will be stable.
4. Long, narrow, and irregularly shaped ponds are preferred, as these configurations are less prone to short-circuiting and tend to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. Irregularly shaped ponds may perform more effectively and will have a more natural appearance.
5. The pond bottom shall be level to facilitate sedimentation.
6. Interior side slopes up to the maximum water surface shall be no steeper than 3H:1V. Exterior side slopes shall be no steeper than 2H:1V.
7. Pond walls may be retaining walls, provided that a fence is provided along the top of the wall, and that at least 25 percent of the pond perimeter will be a vegetated soil slope of not greater than 3H:1V.
8. For berm embankments of 6 feet (1.8 m) or less, (including 1 foot (300 mm) freeboard), the minimum top width shall be 6 feet (1.8 m) or as recommended by the engineer.
9. The toe of the exterior slope of pond berm embankment must be no closer than 5 feet (1.5 m) from the right-of-way.
10. The berm embankment shall be constructed in accordance with Section 2-03.3(14)C Method C of WSDOT Standard Specifications.
11. A "key" must be excavated that is equal to 50 percent of the berm embankment cross-sectional height and width (except on highly compacted till soils where the "key" minimum depth can be reduced to 1 foot (300 mm) of excavation into the till).
12. Anti-seepage collars must be placed on outflow pipes in berm embankments impounding water greater than 8 feet (2.5 m) in depth at the design water surface.

13. Exposed earth on the side slopes shall be sodded or seeded with the appropriate seed mixture as soon as is practicable. Establishment of protective vegetative cover shall be ensured with jute mesh or other protection and reseeded as necessary.

14. The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then baffles can be installed to increase the flow path and water residence time.

15. If a nutrient control wet pond is used during construction, the pond should be cleaned before becoming a permanent erosion control fixture.

16. Detention facility design must take into consideration overflow. Overflow may result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

17. Design with maintenance in mind. Good maintenance will be crucial to successful use of the impoundment. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance should be a basic consideration in design and in determination of first cost.

Design Procedure

1. Calculate the runoff hydrograph for the 6 month 24-hour design storm (See Chapter 3).

2. The nutrient control wet pond shall be designed with a permanent pool volume equal to the runoff volume of the 6-month design storm.

3. The pond surface area to depth relationship shall be such that 30 percent of the pond area has a depth of 0 to 2 feet (0 to 600 mm) and the remainder of the pond has a depth of 2 to 6 feet (600mm to 3.0 m).

4. If the wet pond is not to be used for stormwater quantity control, then design an outlet such as a weir or an orifice that will pass the 100-year event through the pond. Place the invert of the outlet at the same elevation as the top of the dead storage volume. The flow leaving the wet pond will discharge either to a large receiving body or to a quantity control BMP. The pond design is finished after this step is completed.

5. If the wet pond is to be used for quantity control, estimate the volume needed above the dead storage volume. Based the estimate on the difference between the 100-year pre-project and 100-year post-project conditions.

6. Route the 2-year, 10-year, and 100-year post-project storms through the pond, one storm event at a time. An outlet device such as a weir or an orifice must be designed to match each release rate. WaterWorks can be used to design an orifice or analyze a given outlet structure.

7. Continue to alter the pond volume until the allowable release rates are not exceeded. After this is accomplished, the factor of safety must be applied (see Figure 2-6.2) and the design volume must be increased without increasing the depth to establish the final volume.

8. Identify an overflow route to be used in the event that the pond capacity is exceeded. This overflow route should be designed to meet Minimum Requirement No. 2 (Preservation of Natural Drainage Systems).

Construction and Maintenance Criteria

1. Roads in and around the pond shall be constructed according to standard WSDOT practices and meet the following criteria:
   - Maximum Grade: 15 percent to control structure, 20 percent into pond.
   - Provide 40-foot (12 m) minimum outside radius on the access road to the control structure and the turn around to the pond bottom.
   - Fence gates shall be provided for access roads at “straight” sections of road.
   - Access roads shall be 15 feet (4.5 m) in width.
   - Manhole and catch basin lids must be at either edge of an access road or pad and be at least 3 feet (1 m) from a property line.
2. Access shall be limited by a double-posted gate if a fence is required or by bollards. Bollards shall consist of two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.
3. If possible, standing water removed during the maintenance operation must be disposed of to a sanitary sewer at an approved discharge location.
4. Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Sediment deposition should be continually monitored in the basin. Significant concentrations of heavy metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of these treatment facilities. Testing of sediment, especially near points of inflow, should be conducted regularly to determine the leaching potential and level of accumulation of hazardous material before disposal. Contact the regional environmental staff for assistance.
5. Remove litter to keep the dry pond free of external pollution.
6. Check the pond for damage caused by erosion and restabilize areas where there is the potential for continued erosion.
7. Maintain pond shape and depth by removing accumulated sediments that exceed 10 percent of the designed pond depth.

8-3.5 BMP RD.15 — Wet Vault/Tank

Definition

Wet vaults and tanks are underground storage facilities that treat stormwater for water quality through the use of a permanent pool of water that acts as a settling basin. Wet vaults and tanks can also provide stormwater quantity control by adding a live storage volume above the permanent pool.

General Criteria

1. Wet vaults/tanks cannot provide the equivalent level of treatment accomplished by wet ponds because neither biological uptake nor vegetative filtration are available as pollutant removal mechanisms. Gravity-settling of suspended solids is the primary removal mechanism but vaults/tanks are unlikely to be as effective as open ponds in removing particulates because little or no soil layer exists in which to permanently stabilize trapped sediments. Also, being underground, vaults and tanks are more difficult to inspect and maintain. Therefore, they should only be used when more desirable BMPs are not practicable.
2. Wet vaults/tanks shall be a minimum of 20 feet (6 m) from any structure, property line, NGPE, and any septic tank/drain field. All facilities shall be a minimum of 50 feet (15 m) from any steep slope, unless a geotechnical report has addressed the potential impact on a steep slope.
3. The length-to-width ratio at the design surface area shall be no less than 3:1.
4. The vault shall be divided into two cells using a baffle, with the first cell occupying about 25 percent of the area. The top of the baffle wall must be coincident with the depth of the permanent pool.
5. Design with maintenance in mind. Good maintenance will be crucial to successful use of a vault/tank. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and cost.

Design Procedure

1. Route the 6-month 24-hour design storm through the basin to develop a hydrograph.
2. The permanent pool for water quality treatment shall be sized to equal the total volume of the 6-month storm.
3. If the wet vault is to be used for quantity control, estimate the volume needed based on the difference between the 100-year pre-project and 100-year post-project hydrographs.
4. Route the 2-year, 10-year, and 100-year post-project storms through the vault, one storm event at a time. An outlet device such as a weir or an orifice must be designed to match each release rate. WaterWorks can be used to design an orifice or analyze a given outlet structure.
5. Continue to alter the volume until the allowable release rates are not exceeded. After this is accomplished, the factor of safety must be applied (see Figure 2-6.2) and the design volume must be increased without increasing the depth to establish the final volume.
6. An overflow outlet must be provided in the event that the vault/tank capacity is exceeded. This overflow outlet should discharge to the same location as the main outlet.

Construction and Maintenance Criteria

Materials

1. Vaults

    Minimum 3,000 psi (2.11 ¥ 106 kgs/sq meter) structural reinforced concrete. All construction joints must be provided with water stops.

2. Tank

    Pipe material, joints, and protective treatment for tanks shall be in accordance with WSDOT/APWA *Standard Specifications* Section 9.05, and AASHTO designations as noted below:

    Corrugated iron or steel pipe and pipe arch, Treatment 1 through 6.

    Aluminized Type 2 corrugated steel pipe and pipe arch (meets AASHTO designations M274 and M36).

    Steel spiral rib pipe, Treatment 1 through 6.

    Aluminum spiral rib pipe.

    Corrugated aluminum pipe and pipe arch.

    Reinforced concrete pipe.

Structural Stability

1. Vaults

    All vaults shall meet structural requirements for overburden support and HS-20 traffic loading. Cast-in-place wall sections shall be designed as retaining walls. Vaults shall be placed on native material with suitable bedding. Vaults shall not be allowed in fill slopes unless analyzed in a geotechnical report for stability and construction practices.

2. Tanks

    All tanks shall meet structural requirements for overburden support and traffic loading, if appropriate. HS-20 live loads must be accommodated for tanks lying under roadways or parking areas. Metal tank end plates must be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gauge material than the pipe and/or require reinforcing ribs. Tanks shall be placed on native material with a suitable bedding. Tanks shall not be allowed in fill slopes.

3. Buoyancy (Tanks)

    In moderately pervious soils where seasonal ground water may induce flotation, buoyancy tendencies must be balanced by ballasting with backfill, providing concrete anchors, increasing the total weight, or by providing subsurface drains to permanently lower the ground water table. Calculations must be submitted which demonstrate stability.

Minimum Access Requirements

1. Vaults

   Provide one access cover per 50 feet (15 m) of length or width and at least one access cover with ladder to the bottom of the vault per cell. The minimum internal height shall be 7 feet (2 m) and the minimum width shall be 4 feet (1.2 m). The maximum depth to the vault invert shall be 20 feet (6 m).

2. Tanks

   The maximum depth to a tank invert shall be 20 feet (6 m). Spacing between access openings for tanks shall not exceed 100 feet (30 m). 36-inch (0.9 m) minimum diameter CMP riser-type manholes of the same gauge as the tank material may be used for access along the length of the tank and at the up-stream terminus of the tank if the tank is designed with a common inlet/ outlet so that it is a backup system rather than a flow-through system. All tank access openings must be readily accessible by maintenance vehicles.

   Debris and sediment should be removed when the accumulated depth is greater than 10 percent of the diameter of the tank/vault. For instance, a 72-inch (1.8 m) storage tank/vault would require cleaning when the depth of sediment reaches 7 inches (180 mm). Contact the Olympia Service Center Maintenance Office for assistance on proper disposal methods.

8-3.6 BMP RI.05 — Water Quality Infiltration Pond

Definition

A water quality infiltration pond is a facility that provides water quality treatment by storing runoff from the 6-month 24-hour storm and infiltrating it into the soil. Treatment is accomplished through particle settling, biological uptake, and filtration. Runoff from larger storms must be routed to a quantity control BMP.

General Criteria

1. The soil infiltration rate must be greater than 0.5 inches (12 mm) per hour and less than 2.5 inches (65 mm) per hour.
2. The pond shall infiltrate all of the runoff from the 6-month storm within 24-hours after precipitation ends.
3. There shall be at least 3 feet (1 m) of soil from the bottom of the pond to the highest ground water level and the highest impermeable layer.
4. A settling basin must precede the pond.
5. An emergency overflow weir must be provided.
6. Pond depths are generally from 2 to 6 feet (0.6 to 1.8 m).
7. 1 foot (300 mm) of freeboard above the highest design water level must be provided.
8. Side slopes should be no steeper than 3:1. Side slopes should be no steeper than 4:1 if they are to be mowed.

9. There shall be at least 20 feet (6 m) to any up slope structure foundation and 100 feet (30 m) to any down slope structure. There shall be at least 20 feet (6 m) to any Native Growth Protection Easement.

10. The slope of the floor of the infiltration pond shall be 3 percent or less.

Design Procedure

1. Select a location. This will be based on the ability to convey flow to the location and the expected soil conditions of the location. The minimum setback distances must also be met.

2. Conduct a soil investigation and determine the infiltration rate. A minimum of one soils log shall be required for each 5,000 square feet (465 square m) of infiltration pond bottom area with no less than three soils logs per pond. Each soils log shall extend a minimum of 3 feet (1 m) in depth below the bottom of the proposed pond, describe the SCS series of the soil, the textural class of the soil horizon(s) through the depth of the log, and note any evidence of high ground water level. In addition, the location of impermeable soil layers or dissimilar soil layers shall be determined.

   The soil investigation is required for two purposes:

   a. Collect soil samples so that the infiltration rate, f, can be determined.

   b. Determine the depth of the seasonal high water table and impermeable soil layers.

   The design infiltration rate, fd, will be equal to onehalf the infiltration rate found from the soil textural analysis.

   An alternate method for determining design infiltration rate will be to perform an insitu percolation test at each of the soils log location. The design infiltration rate will be equal to one half of the average measured rate.

3. Calculate the size of the of the settling basin. There are many acceptable ways to design a settling basin. The preferred method is to size a basin using the procedure in BMP E3.40 except that instead of using the peak flow rate from the 10-year storm the peak rate from the 6-month storm is used for the calculations.

4. Calculate the post project 6-month storm hydrograph (see Chapter 3).

5. Estimate a pond size based on the total volume of the runoff for the 6-month storm.

6. Route the hydrograph through the pond. An infiltration pond functions in the same way as a dry pond, except that the only outlet is through infiltration. The outlet flow can be calculated as:

   $$Q_{outlet} = f_d * A_s$$

   Where: f_d = design infiltration rate

   A_s = water surface area of the pond

7. Design a flow splitting device such that all flows larger than the peak flow from the 6-month storm are routed around the settling basin and the infiltration pond. Also provide an emergency overflow outlet for the infiltration pond that

routes any excess flow from the pond into the conveyance system for the larger storm flows.

Construction and Maintenance Criteria

Construction

1. The sequence of various phases of pond construction shall be coordinated with the overall project construction schedule. A program should schedule rough excavation of the pond with the rough grading phase of the project to permit use of the material as fill in earthwork areas. The partially excavated pond could serve as a temporary sediment trap in order to assist in erosion and sediment control during construction. However, ponds near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed pond with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the pond floor. Final grade of an infiltration pond shall not be attained until after its use as a sediment control pond is completed.
2. Specifications for pond construction should state the earliest point in construction progress when storm drainage may be directed to the ponds, and the means by which this delay in use should be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as is reasonably possible.
3. Initial pond excavation should be carried to within 1 foot of the final elevation of the pond floor. Final excavation to the finished grade should be deferred until all disturbed areas in the watershed have been stabilized or protected. The final phase of excavation should remove all accumulated sediment. Relatively light-tracked equipment is recommended for this operation to avoid compaction of the pond floor. After the final grading is completed, the pond floor should be deeply tilled by means of rotary tillers or disc harrows to provide a well-aerated, highly porous surface texture.
4. Establishing a healthy stand of vegetation on the pond side slopes and floor is recommended. This vegetation will not only prevent erosion and sloughing, but will also provide a natural means of maintaining relatively high infiltration rates. Erosion protection of inflow points to the pond shall also be provided. Removal of accumulated sediment is a problem only at the pond floor. Little maintenance is normally required to maintain the infiltration capacity of side slope areas.

Maintenance

1. When infiltration ponds are first placed into use they should be inspected on a monthly basis, and more frequently if a large storm occurs in between that schedule. Once it is determined that the pond is functioning in a satisfactory manner and that there are no potential sediment problems, inspection can be reduced to an annual basis with additional inspections following the occurrence of a large storm [e.g., approximately 2 inches (50 mm) in 24 hours].

2. The pond should be designed with maintenance in mind. Access should be provided for vehicles to easily maintain the entrance area and not disturb vegetation, or resuspend sediment any more than is absolutely necessary.
3. Cleanout frequency of infiltration ponds will depend on whether they are vegetated or nonvegetated and will be a function of their storage capacity, recharge characteristics, volume of inflow, and sediment load.
4. Grass bottoms in infiltration ponds seldom need replacement since grass serves as a good filter material. If silty water is allowed to trickle through the turf, most of the suspended material is strained out within a few yards of surface travel. Well established turf on a pond floor will grow up through sediment deposits forming a porous turf and preventing the formation of an impenetrable layer. Grass filtration works well with long, narrow, shoulder-type depressions (swales, ditches, etc.) where highway runoff flows down a grassy slope between the roadway and the pond. Grass planted on pond side slopes will also prevent erosion.
5. Tilling may be necessary to restore the natural infiltration capacity by over-coming the effects of surface compaction, and to control weed growth on the pond floor.
6. Maintenance of side slopes is necessary to promote dense turf with extensive root growth which enhances infiltration through the slope surface, prevents erosion and consequent sedimentation of the pond floor, and prevents invasive weed growth.
7. Seed mixtures should recommended by the district or headquarters landscape architect or the headquarters horticulturist.

8-4 Water Quantity BMPs

8-4.1 BMP RD.11 — Dry Pond

Definition

A dry pond is a facility that provides stormwater quantity control by containing excess runoff in a detention basin, then releasing the runoff at allowable levels. A water quality BMP must precede a dry pond.

General Criteria

1. Dry pond site selection should consider both the natural topography of the area and right of way boundaries. The planting and preservation of vegetation should be an integral part of the storage facility design.
2. Dry pond design must take into consideration overflow. Overflow may result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.
3. Interior side slopes up to the maximum water surface shall be no steeper than 3H:1V. Exterior side slopes shall be no steeper than 2H:1V. Slopes should be no steeper than 4H:1V if they are to be mowed.

4. Pond walls may be retaining walls, provided that a fence is provided along the top of the wall, and that at least 25 percent of the pond perimeter will be a vegetated soil slope of not greater than 3H:1V.
5. For berm embankments of 6 feet (1.8 m) or less, the minimum top width shall be 6 feet (1.8 m).
6. The toe of the exterior slope of pond embankment must be no closer than 5 feet (1.5 m) from the right of way line.
7. Pond berm embankment must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical engineer) free of loose surface soil materials, roots and other organic debris.
8. Pond berm embankments must be constructed by excavating a “key” equal to 50 percent of the berm embankment cross-sectional height and width (except on highly compacted till soils where the “key” minimum depth can be reduced to 1 foot (300 mm) of excavation into the till).
9. The berm embankment shall be constructed in accordance with Section 2-03.3(14)C Method C of WSDOT *Standard Specifications*.
10. Anti-seepage collars must be placed on outflow pipes in berm embankments impounding water greater than 8 feet (2.5 m) in depth at the design water surface.
11. Exposed earth on the pond bottom and side slopes shall be sodded or seeded with the appropriate seed mixture as soon as is practicable. Establishment of protective vegetative cover shall be ensured with jute mesh or other protection and reseeded as necessary.
12. The dry pond must be cleaned before becoming a permanent BMP if it was used as a retention pond during the construction stage.
13. Design with maintenance in mind. Good maintenance will be crucial to successful use of the pond.

Design Criteria

1. Calculate the pre-project and post project hydrographs for the 2-year, 10-year, and 100-year storms (see Chapter 3).
2. Estimate the initial pond size based on the difference between the 100-year pre-project and 100-year post-project hydographs.
3. Route the 2-year, 10-year, and 100-year post-project storms through the pond, one storm event at a time. An outlet device such as a weir or an orifice must be designed to match each release rate. WaterWorks can be used to design an orifice or analyze a given outlet structure.
4. Continue to alter the volume until the allowable release rates are not exceeded. After this is accomplished, the factor of safety must be applied (see Figure 2-6.2) and the design volume must be increased without increasing the depth to establish the final volume.

5. Identify an overflow route to be used in the event that the pond capacity is exceeded. This overflow route should be designed to meet Minimum Requirement No. 2 (Preservation of Natural Drainage Systems).

Construction and Maintenance Criteria

1. Roads in and around the dry pond shall be constructed according to standard WSDOT practices and meet the following criteria:
   - Maximum Grade: 15 percent to control structure, 20 percent into pond.
   - Provide 40-foot (12-m) minimum outside radius on the access road to the control structure and the turn around to the pond bottom.
   - Fence gates shall be provided for access roads at “straight” sections of road.
   - Access roads shall be 15 feet (4.5 m) in width.
   - Manhole and catch basin lids must be at either edge of an access road or pad and be at least 3 feet (1 m) from a property line.
2. Access shall be limited by a double-posted gate if a fence is required or by bollards. Bollards shall consist of two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.
3. Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Sediment deposition should be continually monitored in the basin. Significant concentrations of heavy metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of these treatment facilities. Testing of sediment, especially near points of inflow, should be conducted regularly to determine the leaching potential and level of accumulation of hazardous material before disposal.
4. Remove litter to keep the dry pond free of external pollution.
5. Check the pond for damage caused by erosion and restabilize areas where there is the potential for continued erosion.
6. Maintain pond shape and depth by removing accumulated sediments that exceed 10 percent of the designed pond depth.

8-4.2 BMP RD.20 — Dry Vault/Tank

Definition

A dry vault/tank is a facility that treats stormwater for water quantity control by detaining runoff and then releasing reduced flows at established standards. Dry vaults/tanks are not to be used for stormwater quality treatment purposes because of their limited pollution removal capabilities. Dry vaults/tanks must always be preceded by a BMP which has been sized to treat the 6-month storm. Because dry vault/tanks are underground, they are more difficult to inspect and maintain. Vaults/tanks shall be permitted for use only on small sites, and then only after it has been demonstrated that more desirable BMPs are not practicable.

General Criteria

1. This BMP must be used in conjunction with a BMP that will fully treat runoff from the 6-month storm.
2. Dry vaults/tanks shall be a minimum of 20 feet (6 m) from any structure, right of way line, Native Growth Protection Easement (NGPE), and from any septic tank/drain field. All facilities shall be a minimum of 50 feet (15 m) from any steep slope. A geotechnical report must address the potential impact on a steep slope.
3. Design with maintenance in mind. Good maintenance will be crucial to successful use of a vault/tank. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost.

Design Procedure

1. Calculate the existing condition and post project hydrographs for the 2-year, 10-year, and 100-year storms (see Chapter 3).
2. Estimate the initial pond size based on the difference between the 100-year pre-project and 100-year post-project hydrographs.
3. Route the 2-year, 10-year, and 100-year post-project storms through the vault, one storm event at a time. An outlet device such as a weir or an orifice must be designed to match each release rate. WaterWorks can be used to design an orifice or analyze a given outlet structure.
4. Continue to alter the volume until the allowable release rates are not exceeded. After this is accomplished, the factor of safety must be applied (see Figure 2-6.2) and the design volume must be increased without increasing the depth to establish the final volume.
5. An overflow outlet must be provided in the event that the vault/tank capacity is exceeded. This overflow outlet should discharge to the same location as the main outlet.

Construction and Maintenance Criteria

Materials

1. Vaults

   Minimum 3,000 psi (2.11x106 kgs/sq meter) structural reinforced concrete. All construction joints must be provided with water stops.

2. Tank

   Pipe material, joints, and protective treatment for tanks shall be in accordance with WSDOT/APWA *Standard Specifications* Section 9.05, and AASHTO designations as noted below:

   Corrugated iron or steel pipe and pipe arch, Treatment 1 through 6.

   Aluminized Type 2 corrugated steel pipe and pipe arch (meets AASHTO designations M274 and M36).

Steel spiral rib pipe, Treatment 1 through 6.

Aluminum spiral rib pipe.

Corrugated aluminum pipe and pipe arch.

Reinforced concrete pipe.

Structural Stability

1. Vaults

   All vaults shall meet structural requirements for overburden support and HS-20 traffic loading. Cast-in-place wall sections shall be designed as retaining walls. Vaults shall be placed on native material with suitable bedding. Vaults shall not be allowed in fill slopes unless analyzed in a geotechnical report for stability and construction practices.

2. Tanks

   All tanks shall meet structural requirements for overburden support and traffic loading, if appropriate. HS-20 live loads must be accommodated for tanks lying under roadways or parking areas. Metal tank end plates must be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gauge material than the pipe and/or require reinforcing ribs. Tanks shall be placed on native material with a suitable bedding. Tanks shall not be allowed in fill slopes.

3. Buoyancy (Tanks)

   In moderately pervious soils where seasonal ground water may induce flotation, buoyancy tendencies must be balanced by ballasting with backfill, providing concrete anchors, increasing the total weight, or by providing subsurface drains to permanently lower the ground water table. Calculations must be submitted which demonstrate stability.

Minimum Access Requirements

1. Vaults

   Provide one access cover per 50 feet (15 m) of length or width and at least one access cover with ladder to the bottom of the vault per cell. The minimum internal height shall be 7 feet (2 m) and the minimum width shall be 4 feet (1.2 m). The maximum depth to the vault invert shall be 20 feet (6 m).

2. Tanks

   The maximum depth to a tank invert shall be 20 feet (6 m). Spacing between access openings for tanks shall not exceed 100 feet (30 m). 36-inch (1-m) minimum diameter CMP riser-type manholes of the same gauge as the tank material may be used for access along the length of the tank and at the up-stream terminus of the tank if the tank is designed with a common inlet/outlet so that it is a backup system rather than a flow-through system. All tank access openings must be readily accessible by maintenance vehicles.

Debris and sediment should be removed when the accumulated depth is greater than 10 percent of the diameter of the tank/vault. For instance, a 72-inch (1.8-m) storage tank/vault would require cleaning when the depth of sediment reaches 7 inches (180 mm). Contact the Olympia Service Center Maintenance Office for assistance on proper disposal methods.

8-4.3 BMP RI.06 — Infiltration Pond

Definition

An infiltration pond is a facility that provides stormwater quantity control by containing excess runoff in a detention facility, then percolating that runoff into the surrounding soil.

General Criteria

1. The soil infiltration rate shall be at least 6 inches (150 mm) per hour.
2. The pond shall be able to infiltrate the 10-year storm out of the pond within 24 hours after precipitation has ended and the 100-year storm within 48 hours after precipitation has ended.
3. There shall be at least 3 feet (1 m) of soil from the bottom of the pond to the highest ground water level and the highest impermeable layer.
4. Pond depths are generally from 2 to 6 feet (0.6 to 1.8 m).
5. There shall be at least 20 feet (6 m) to any up slope structure foundation and 100 feet (30 m) to any down slope structure. There shall be at least 20 feet (6 m) to any NGPE.
6. The slope of the floor of the infiltration pond shall be 3 percent or less.

Design Procedure

1. Select a location. This will be based on the ability to convey flow to the location and the expected soil conditions of the location. The minimum setback distances must also be met.
2. Conduct a soil investigation and determine the infiltration rate. A minimum of one soils log shall be required for each 5,000 square feet (465 square m) of infiltration pond bottom area with no less than three soils logs per pond. Each soils log shall extend a minimum of 3 feet (1 m) in depth below the bottom of the proposed pond, describe the SCS series of the soil, the textural class of the soil horizon(s) through the depth of the log, and note any evidence of high ground water level. In addition, the location of impermeable soil layers or dissimilar soil layers shall be determined.

   The soil investigation is required for two purposes:

   a. Collect soil samples so that the infiltration rate, f, can be determined.
   b. Determine the depth of the seasonal high water table and impermeable soil layers.

   The design infiltration rate, f_d, will be equal to one half the infiltration rate found from the soil textural analysis.

An alternate method for determining design infiltration rate will be to perform an in-situ percolation test at each of the soils log location. The design infiltration rate will be equal to one half of the average measured rate.

3. Calculate the postproject 100-year storm hydrograph (see Chapter 3).
4. Estimate a pond size based on the total volume of the runoff for the 100-year storm.
5. Route the hydrograph through the pond. An infiltration pond functions in the same way as a dry pond, except that the only outlet is through infiltration. The outlet flow can be calculated as:

$$Q_{outlet} = f_d * A_s$$

Where: f_d = design infiltration rate

A_s = water surface area of the pond

6. Rearrange the pond configuration until the volume of the pond is not exceeded during the 100-year design storm. The pond must drain the 100-year design storm within 48 hours after the precipitation has ended.
7. Identify an overflow route to be used in the event that the pond capacity is exceeded. This overflow route should be designed to meet Minimum Requirement No. 2 (Preservation of Natural Drainage Systems).
8. The embankment, emergency spillways, spoil and borrow areas, and other disturbed areas shall be stabilized and planted in accordance with Minimum Requirement No. 1 (Erosion and Sediment Control).

Construction and Maintenance Criteria

Construction

1. The sequence of various phases of pond construction shall be coordinated with the overall project construction schedule. A program should schedule rough excavation of the pond with the rough grading phase of the project to permit use of the material as fill in earthwork areas. The partially excavated pond could serve as a temporary sediment trap in order to assist in erosion and sediment control during construction. However, ponds near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed pond with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the pond floor. Final grade of an infiltration pond shall not be attained until after its use as a sediment control pond is completed.
2. Specifications for pond construction should state the earliest point in construction progress when storm drainage may be directed to the ponds, and the means by which this delay in use should be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as is reasonably possible.
3. Initial pond excavation should be carried to within 1 foot of the final elevation of the pond floor. Final excavation to the finished grade should be deferred until all disturbed areas in the watershed have been stabilized or protected.

The final phase of excavation should remove all accumulated sediment. Relatively light-tracked equipment is recommended for this operation to avoid compaction of the pond floor. After the final grading is completed, the pond floor should be deeply tilled by means of rotary tillers or disc harrows to provide a well-aerated, highly porous surface texture.

4. Establishing a healthy stand of vegetation on the pond side slopes and floor is recommended. This vegetation will not only prevent erosion and sloughing, but will also provide a natural means of maintaining relatively high infiltration rates. Erosion protection of inflow points to the pond shall also be provided. Removal of accumulated sediment is a problem only at the pond floor. Little maintenance is normally required to maintain the infiltration capacity of side slope areas.

Maintenance

1. When infiltration ponds are first placed into use they should be inspected on a monthly basis, and more frequently if a large storm occurs in between that schedule. Once it is determined that the pond is functioning in a satisfactory manner and that there are no potential sediment problems, inspection can be reduced to an annual basis with additional inspections following the occurrence of a large storm [e.g., approximately 2 inches (50 mm) in 24 hours].
2. The pond should be designed with maintenance in mind. Access should be provided for vehicles to easily maintain the entrance area and not disturb vegetation, or resuspend sediment any more than is absolutely necessary.
3. Cleanout frequency of infiltration ponds will depend on whether they are vegetated or nonvegetated and will be a function of their storage capacity, recharge characteristics, volume of inflow, and sediment load.
4. Grass bottoms in infiltration ponds seldom need replacement since grass serves as a good filter material. If silty water is allowed to trickle through the turf, most of the suspended material is strained out within a few yards of surface travel. Well established turf on a pond floor will grow up through sediment deposits forming a porous turf and preventing the formation of an impenetrable layer. Grass filtration works well with long, narrow, shoulder-type depressions (swales, ditches, etc.) where highway runoff flows down a grassy slope between the roadway and the pond. Grass planted on pond side slopes will also prevent erosion.
5. Tilling may be necessary to restore the natural infiltration capacity by over-coming the effects of surface compaction, and to control weed growth on the pond floor.
6. Maintenance of side slopes is necessary to promote dense turf with extensive root growth which enhances infiltration through the slope surface, prevents erosion and consequent sedimentation of the pond floor, and prevents invasive weed growth.
7. Seed mixtures should recommended by the district or headquarters landscape architect or the headquarters horticulturist.

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